

## CHAPTER 5

### THE COMMUNICATIONS SUBSYSTEM

In today's Navy, rapid exchange of information is essential to the efficient and effective completion of a ship or station's mission. You, as a technician, have the responsibility of maintaining the communications equipment in fully operational condition. In order to accomplish the maintenance required, you will need to master not only the equipment and its operating

principles; but also its use and location within the communication subsystem.

The Master Clock, RF, Transmit and Receive Subsystems were discussed in the preceding chapters. The Communication Subsystem (Figure 5-1), as discussed in this chapter, is another block in the overall operational system.

There are several types of equipment used in a communications subsystem. The type of

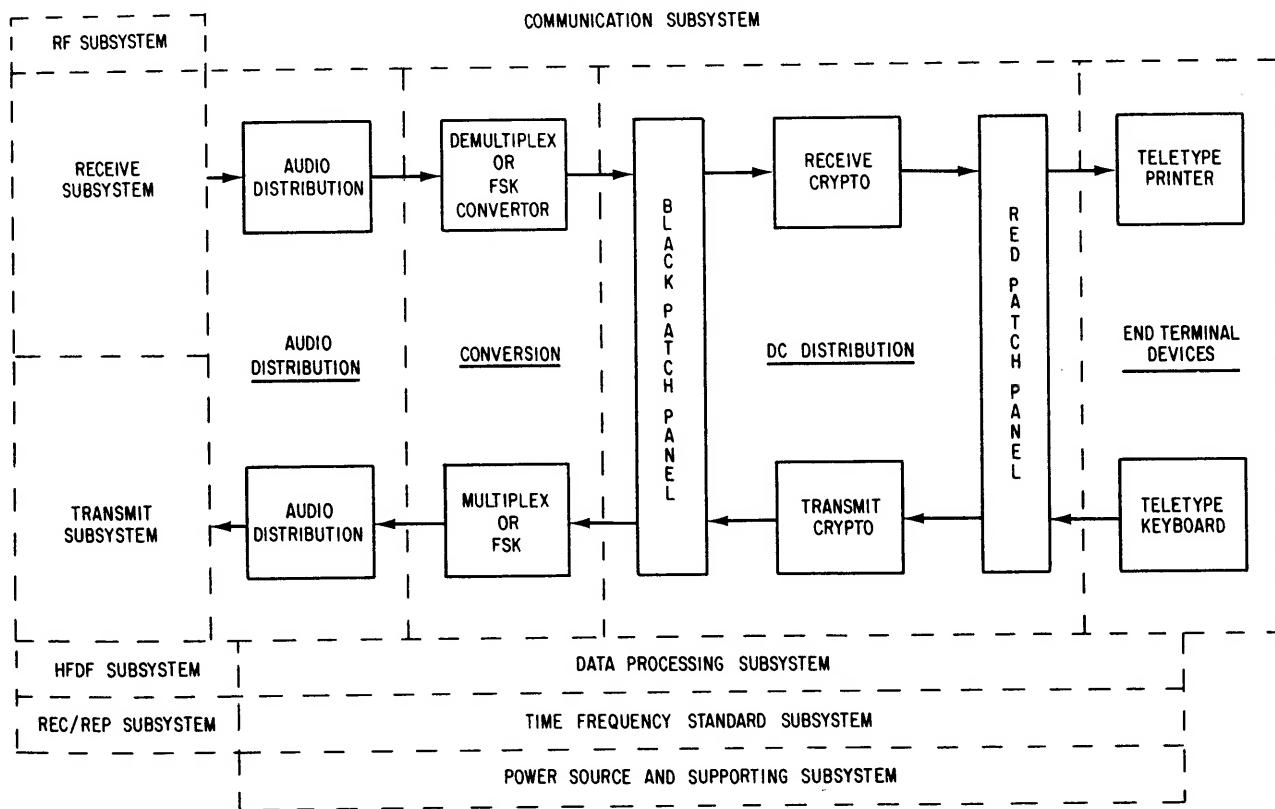


Figure 5-1.—Communication Subsystem.

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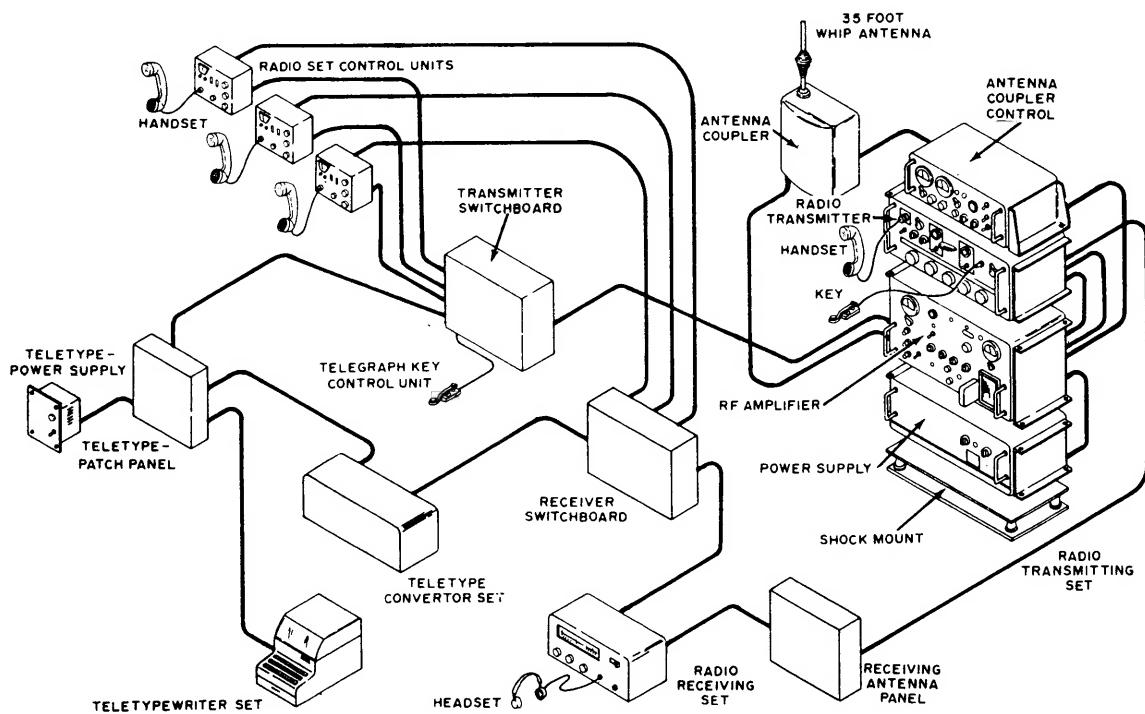


Figure 5-2.—Communication System.

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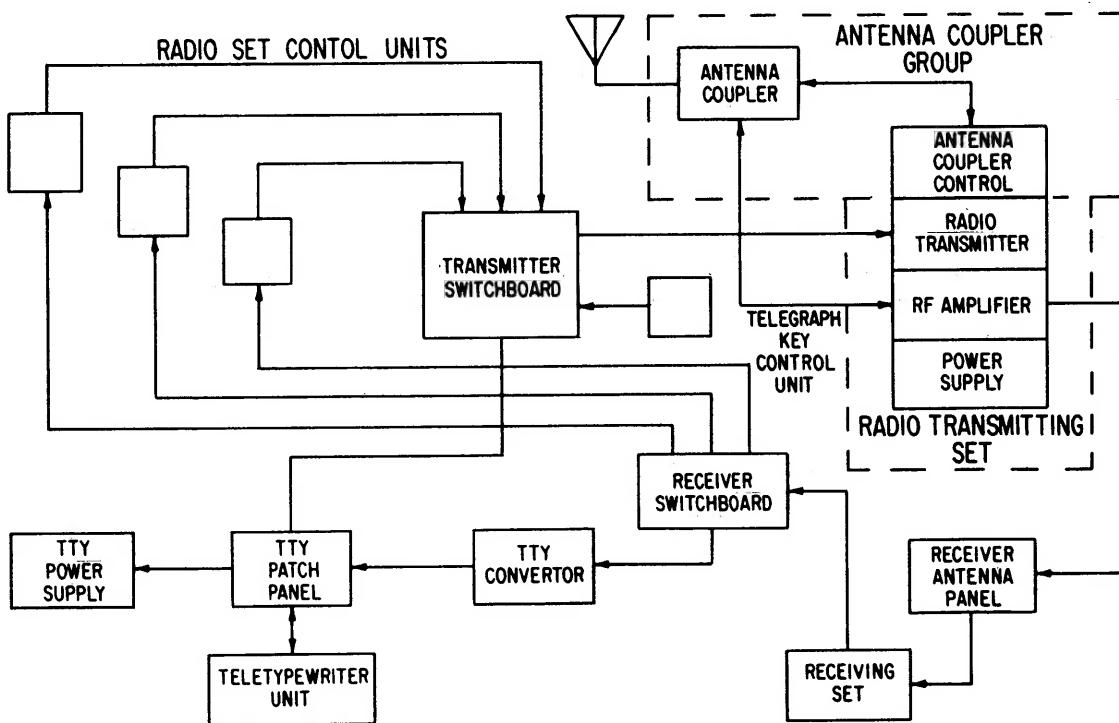


Figure 5-3.—Communication System (Block Diagram).

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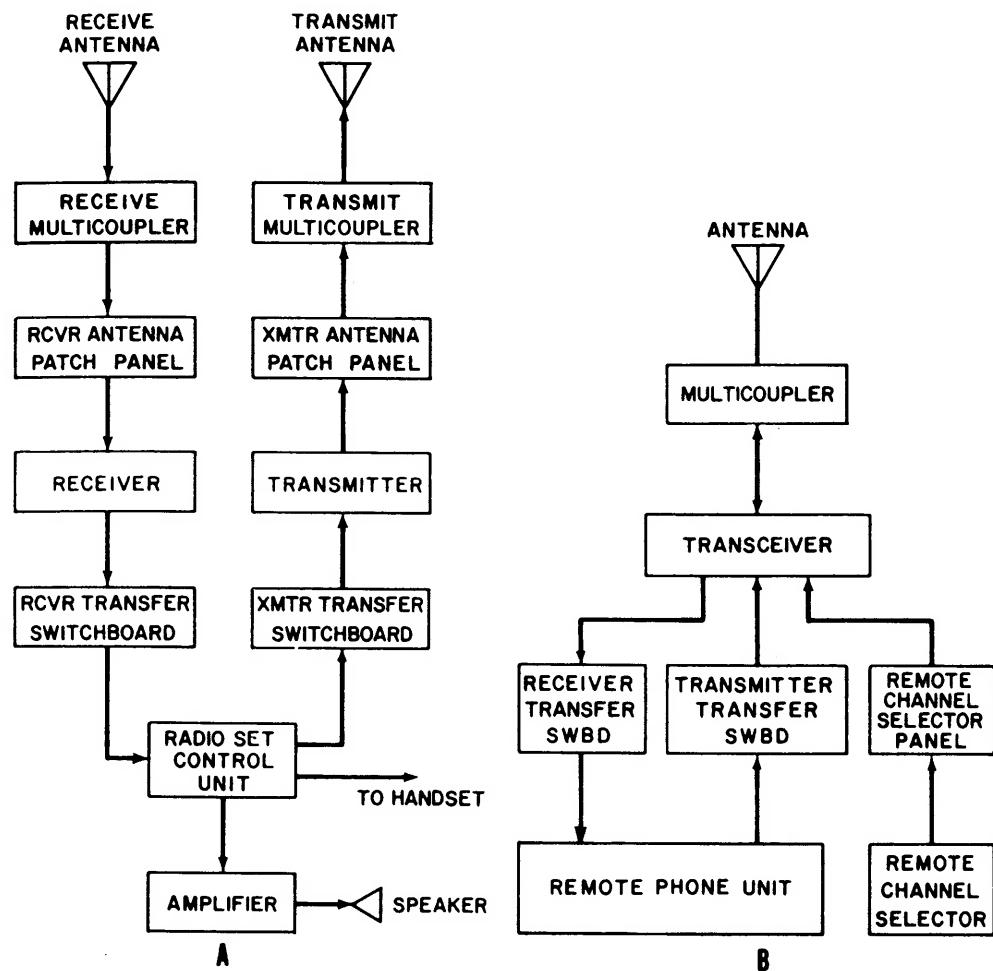


Figure 5-4.—Nonsecure Voice Systems.

120.66 equipment used will depend upon the manner in which the intelligence is to be transmitted or received. The intelligence may be in the form of voice, TTY, CW, facsimile, or data stream.

### COMMUNICATION SYSTEMS

Figure 5-2 is an overall pictorial view of a complete communications system containing the necessary components for transmission and reception of voice, CW, and teletype signals. Figure 5-3 is a block diagram of the same system with the arrows showing the direction of signal flow.

### Voice Communication Subsystems

162.130 Voice Communication subsystems as used in the Navy are of two types, amplitude or frequency modulation. Either amplitude or frequency modulation may be used provided all units in the voice net use the same mode of emissions (all on AM or all on FM). A typical non-secure voice system consists of one or more radio set control units, usually referred to as radiophone or remote phone units (RPUs), patched to transmitter and receiver sets (or transceivers) via transfer switchboards (fig. 5-4A). If remote channel selection is required

the remote channel selector is patched through a separate switch panel (fig. 5-4B).

The push-to-talk button on the handset closes the d.c. keying circuit to the transmitter, (fig. 5-4A) placing the transmitter on the air. The audio signal and d.c. keying voltage from the handset are patched through the transmitter transfer switchboard to the transmitter. The audio signal modulates the RF signal generated by the transmitter, and this modulated RF signal is radiated by the transmitter antenna.

On the receive side, the RF signal is picked up by the receiver antenna and fed through the coupler or multicoupler to the receiver where demodulation takes place, resulting in an audio signal output. This audio signal output from the receiver is patched through the receiver transfer switchboard to the RPU and loudspeaker.

## SECURE VOICE COMMUNICATIONS

Wideband UHF/VHF secure voice is used extensively for line-of-sight voice communications. A typical system (fig. 5-5) consists of the antenna connected through a coupler or multicoupler to a transceiver. The transceiver is patched through the switchboards to security (crypto) equipment. The security equipment is connected through a matrix or network to the remote phone units.

When the operator speaks into the handset, the audio signals are patched through the matrix to the security equipment. The security equipment encrypts (scrambles) the audio signals. The encrypted signals are then applied to the transmitter section of the transceiver where they modulate the RF carrier and are radiated by the antenna system.

The modulated RF carrier is received and demodulated by the receiver section of the transceiver, resulting in encrypted audio signals. The encrypted audio signals are then applied to the security equipment where they are decrypted (unscrambled) and converted back to audio signals. The audio signals are then patched through the matrix to the remote phone unit.

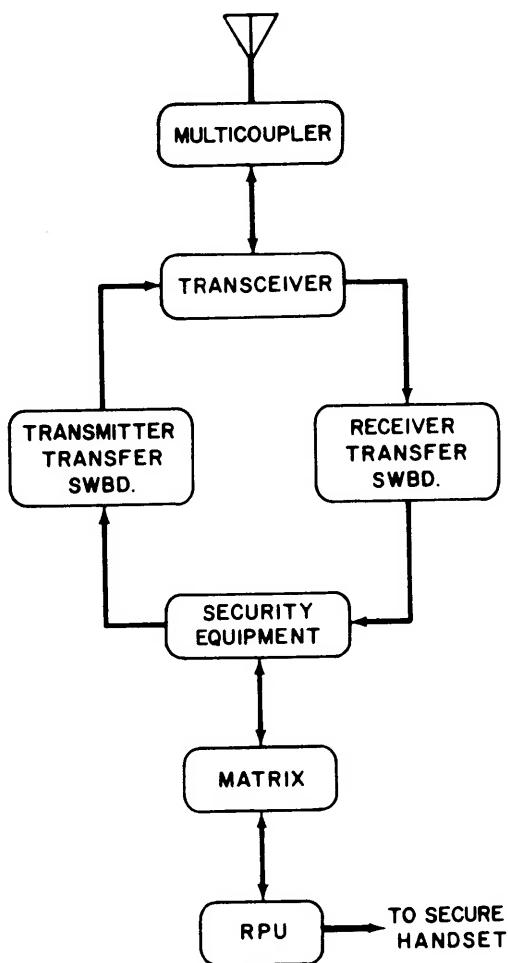


Figure 5-5.—Secure Voice System.

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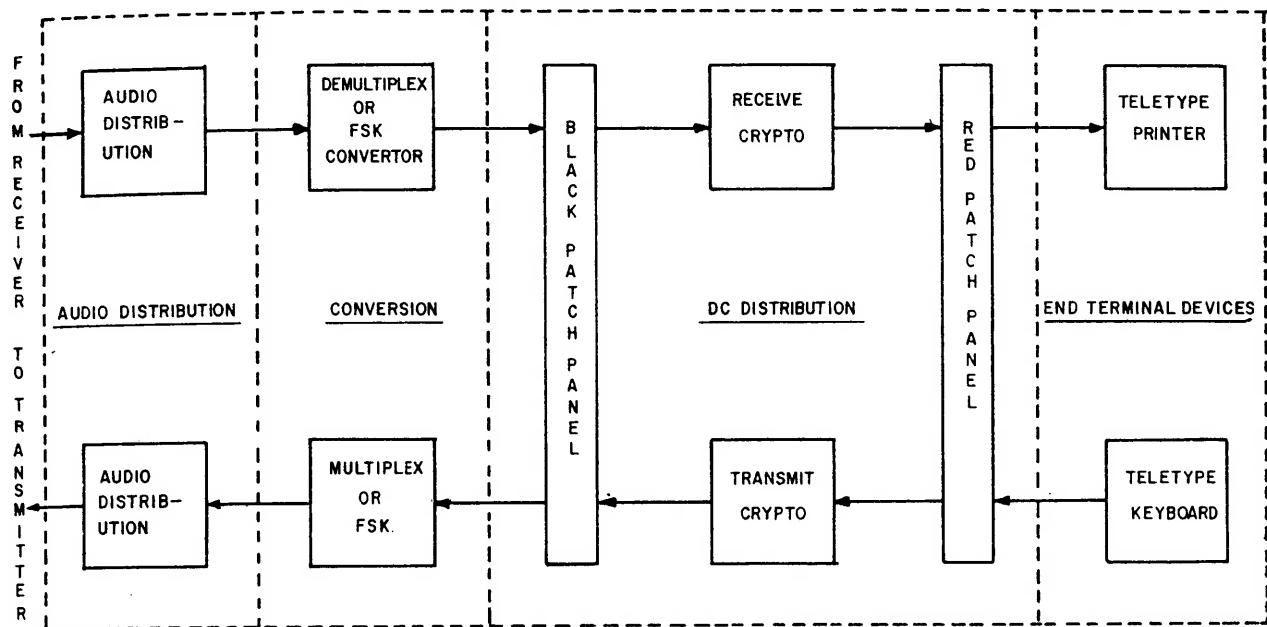
## Secure Teletype Communication Subsystem

Figure 5-6 illustrates the signal flow in a secure teletype communication subsystem, and is described in the following paragraphs.

The audio signal from the receiver must first pass through a receiver transfer switchboard (audio distribution) where it is switched to the desired conversion equipment. The conversion equipment (demultiplex or FSK converter) will either demultiplex the audio signal and convert it to a teletype signal or in the case of a single channel FSK (frequency shift keying) reception,

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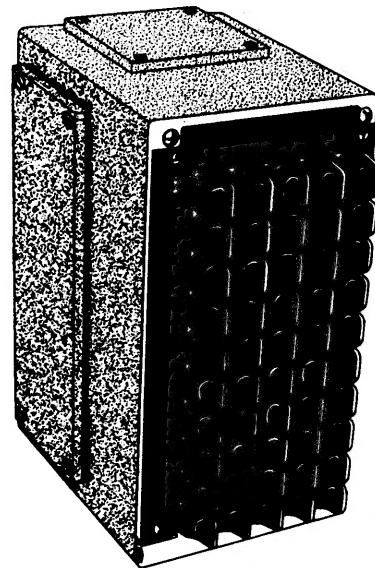


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Figure 5-6.—Signal Flow for a Secure Teletype Communication Subsystem.

it will be converted directly to a teletype signal. At this point the TTY signal is fed to the "BLACK" (unclassified/encrypted signals) patch panel where it is patched to a decryption device (receive crypto) for decryption to a plain text teletype signal. After decryption it is fed to the "RED" (classified/decrypted signals) patch panel where it is patched to the receiving teletype equipment for print-out.

On the transmit side, the signal flow is similar to the receive side in reverse. The teletype signal to be transmitted is originated by the sending teletype equipment (TTY keyboard) and passed to the "RED" patch panel, where it is patched to the encrypting device (transmit crypto) for encryption to cipher text. After encryption, the teletype signal is fed to the "BLACK" patch panel where it is patched directly to the transmitter's frequency shift keyer or to the multiplex equipment where it is mixed with other signals to be transmitted. Upon completion of conversion to an audio signal, it is routed to the transmitter via the transmitter transfer switchboard (Audio Distribution).



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Figure 5-7.—External View of the Receiver Switchboard Type SB-82/SRR.

It should be noted that the transmitter and receiver are not always colocated, for example; the transmitter site may be located as far as 32.186 kilometers (20 miles) from the receiver site. In this instance, the signal would be sent via land line or microwave from the receiver site to the transmitter site for transmission.

### AUDIO DISTRIBUTION

Transferring the audio output of a receiver to its various end use equipments, and conversely from the converters to the transmitter, requires an intricate switching capability. The most common equipment in use

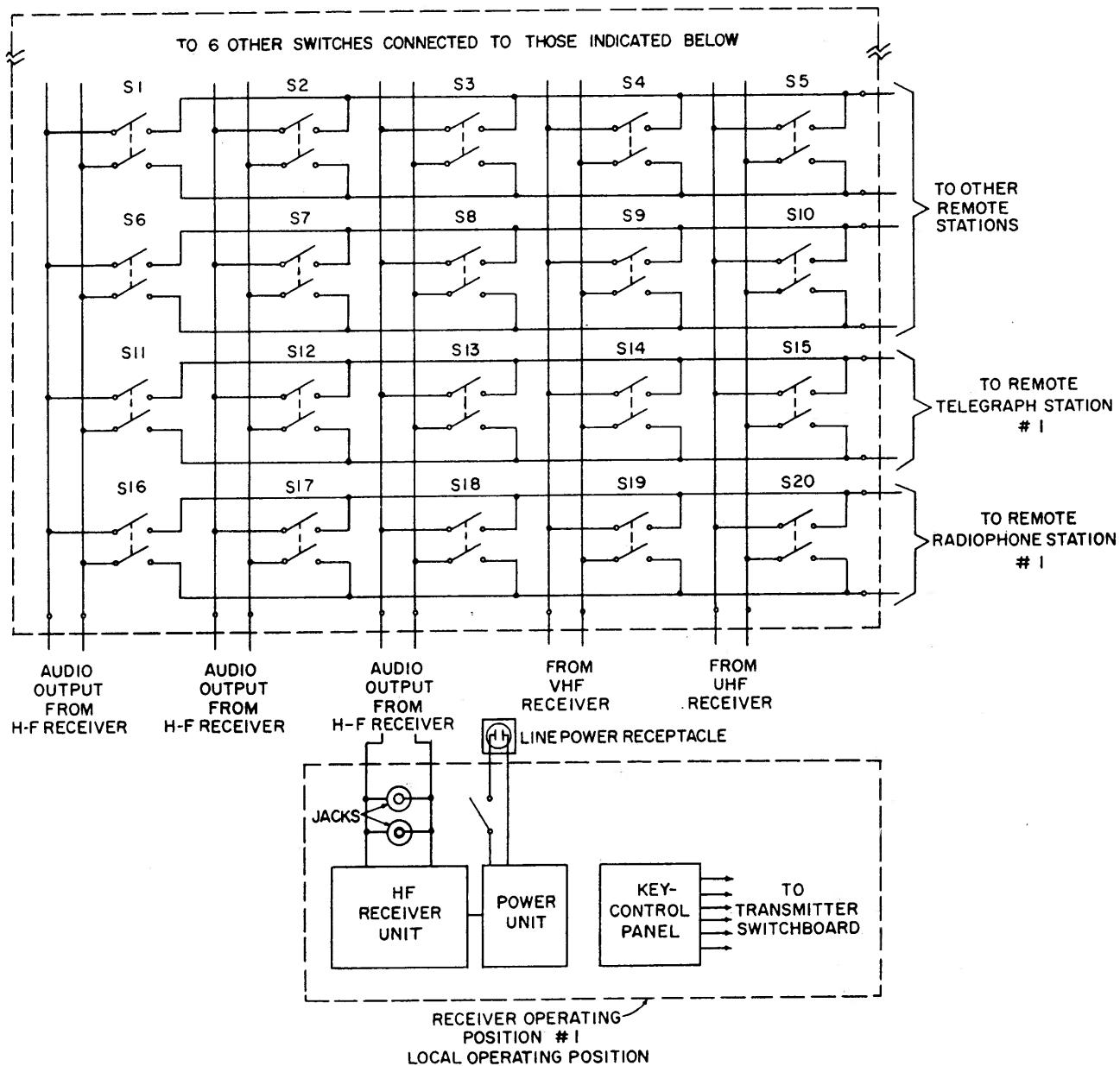


Figure 5-8.—Simplified Schematic Diagram of the Receiver Transfer Switchboard Type SB-82/SRR.

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at present provides the flexibility needed by using switches thrown in a desired pattern.

### RECEIVER TRANSFER SWITCHBOARD

An external view of the Receiver Transfer Switchboard, Type SB-82/SRR, is shown in figure 5-7.

The receiver switchboard has 5 vertical rows of 10 double-pole, single-throw switches that are continuously rotatable in either direction.

One side of each switch within a vertical row is wired in parallel with the same sides of the other nine switches within that row. Similarly, the other side of each switch is wired in parallel with the corresponding sides of each of the other four switches in a horizontal row.

The audio output from the receiving equipments, connected to the five vertical rows of switches, may be fed to any or all of the converters by closing the proper switch or switches, thus providing a high degree of flexibility.

The knob of each switch is marked with a heavy white line to provide visual indication of the communication setup. Switchboards are normally mounted in a vertical position, as shown in Figure 5-7. This arrangement permits the outputs from 5 receivers to be fed to the 5 vertical rows and up to 10 converters to be fed from the 10 horizontal rows of switches.

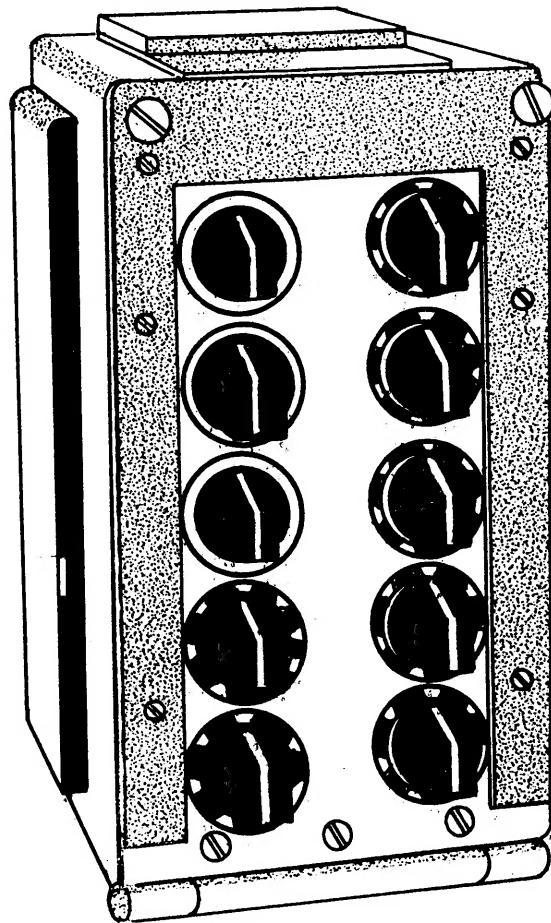
If it becomes necessary to employ a system with 10 receivers and 5 converters, the switchboard may be mounted in a horizontal position with each switch knob rotated 90° with respect to the shaft. All shafts have two flat sides for setscrews so that this change can be made if desired. The purpose of rotating the switch knobs with respect to the shaft is to standardize the setup so that the switches will be in the OFF position when the white line is in a vertical position. To further standardize all installations, receivers are always connected to the vertical rows of switches, and converters are always connected to the horizontal rows of switches; after the orientation (vertical or horizontal) of the switchboard has been determined.

It should be noted (see figure 5-8) that only the receiver audio output circuit is connected to the switchboard.

### Receiver Transfer Switchboard SB-973/SRR

Another model receiver transfer switchboard is the SB-973/SRR (figure 5-9). This switchboard contains 10 seven-position rotary selector switches. Each switch or operating knob provides a connection to a remote control station. Switch positions one through five are receiver output connections.

Position X on each switch serves to transfer the remote control stations connected to the



120.16

Figure 5-9.—Receiver Transfer Switchboard (SB-973/SRR).

original switchboard to the corresponding switches in additional switchboards. In this manner, any one of a number of receivers can be connected to any of the ten remote control stations. An additional switchboard is needed for each five additional receivers.

Switchboards providing facilities for additional remote control stations are mounted in vertical sequence, whereas those containing additional receivers are mounted in horizontal sequence.

### TRANSMITTER TRANSFER SWITCHBOARD

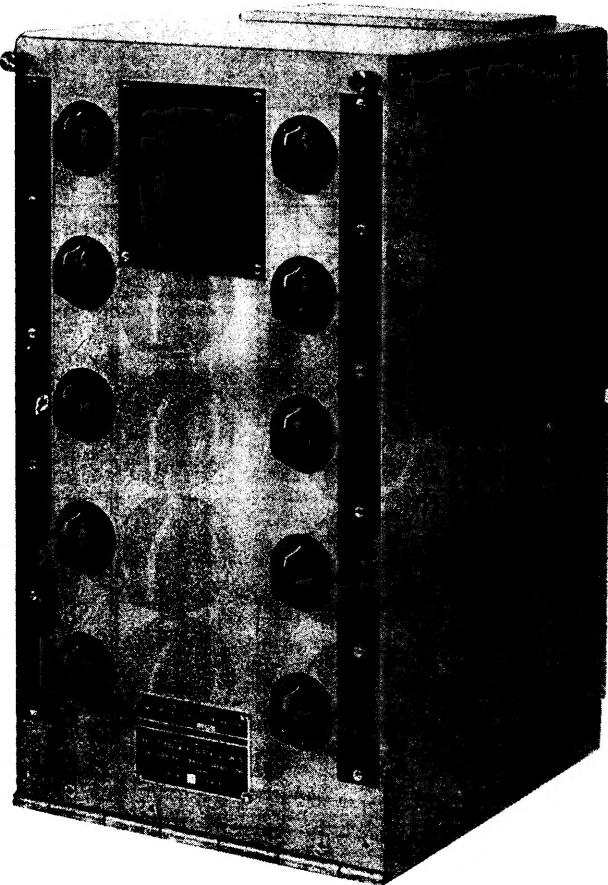
The transmitter transfer switchboard provides facilities for selectively transferring

remote control station functions and signals to the transmitters. A representative transfer switchboard (Figure 10) provides facilities for selectively transferring any one, or all, of ten remote control station functions and signals to any one of six transmitters. The cabinet has ten rotary switches, arranged in two vertical rows of five switches each. Arrangement of the circuitry is such that it is impossible to parallel transmitter control circuits, that is to connect more than one transmitter to any remote control station.

### BASIC PRINCIPLES OF TELETYPE COMMUNICATIONS

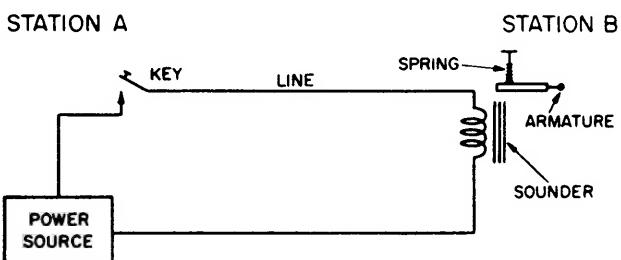
To see how intelligence is sent via teletype, one of the simpler devices for electrical communications—the manual telegraph circuit—is first considered. This circuit, shown in figure 5-11, includes a telegraph key, a source of power (battery), a sounder, and a movable sounder armature. If the key is closed, current flows through the circuit and the armature is attracted to the sounder by magnetism. When the key is opened, the armature is retracted by a spring. With these two electrical conditions of the circuit—closed and open—it is possible, by means of a code, to transmit intelligence. These two conditions of the circuit are referred to as MARKING and SPACING. MARKING occurs when the circuit is closed, and a current flows; the SPACING occurs when it is open, and no current flows.

If the key at station A is replaced by a transmitting teletypewriter and the sounder



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Figure 5-10.—Transmitter Transfer Switchboard (SB-988/SRT).



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Figure 5-11.—Manual Telegraph Circuit.

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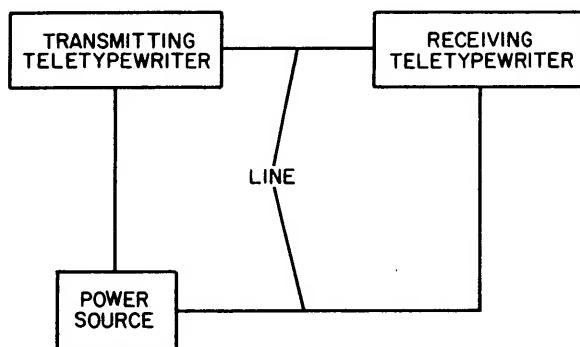
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arrangement at station B is replaced by a receiving teletypewriter, the basic teletypewriter circuit shown in figure 5-12 is formed.

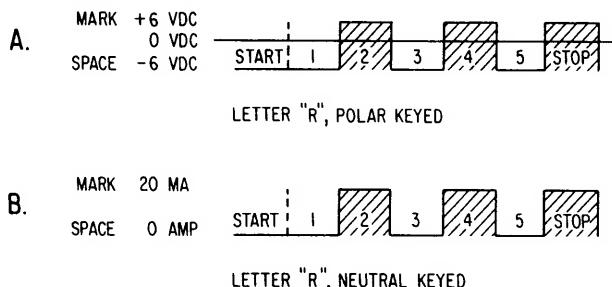
If a teletypewriter signal could be drawn on paper, it would resemble figure 5-13. This is the code combination for the letter R. Shaded areas show intervals during which the circuit is closed, and the blank areas show the intervals during which the circuit is open. There are a total of seven units in the signal. Five of these are numbered, and are called INTELLIGENCE units. The first and last units of the signal are labeled START and STOP. They are named after their functions: the first starts the signal, and last stops it. These are a part of every teletypewriter code signal; the START unit is always spacing, and the STOP unit is always marking.

Examine figure 5-13 again. This is theoretically a perfect signal. The time between



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Figure 5-12.—Simple Teletype Circuit.



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Figure 5-13.—Representation of the Character "R" Using 5-Level Code.

each unit remains the same during its transmission and the shift from mark to space (and vice versa) is called a TRANSITION. A transition occurs at the beginning and end of each unit when it shifts from mark to space or space to mark, and there will be only 2, 4, or 6 transitions for each character.

A circuit which uses a current/no current condition to pass intelligence (shown in figure 5-13A) is called a NEUTRAL keyed circuit. Another type of keying is POLAR keying (see figure 5-13B). Where neutral keying uses current/no current, polar keying uses positive and negative voltages.

## CODES

In manual telegraphy, the most widely used code is the Morse code. In this code, two distinctive signal elements are employed, the dot and the dash. The difference between a dot and a dash is usually one of time duration, a dash being three times as long in duration as a dot. Each character is made up of a number of dots and/or dashes. The dot and dash elements constituting any character are separated from each other by a time interval equal to the duration of one dot. The time interval between the characters for each is equal to the duration of three dots, and the interval between words is equal to seven dots.

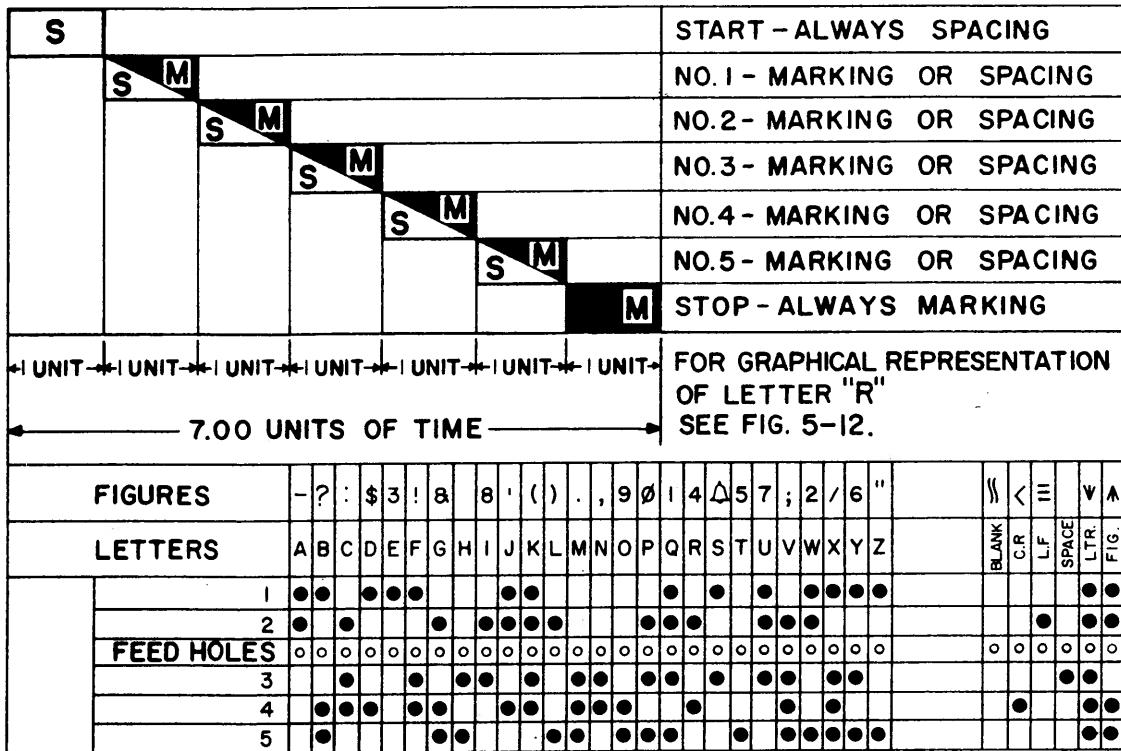
In teletypewriter operation, the code group for each character is of uniform length. Since the Morse code is an uneven length code, it cannot be used in teletypewriter operation, without additional code converters.

### Five-Level Teletypewriter Code

The 5-unit (5-level) code (Figure 5-14) has been the most commonly used code in modern printing telegraphy, and is universally employed for teletypewriter operation. The mechanical sending device in the teletypewriter divides the sending time for each character into five short

## 7.00-UNIT TRANSMISSION PATTERN

## TRANSMISSION SEQUENCE



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**Figure 5-14.—5-Level Teletypewriter Code.**

code elements (impulses) of equal duration. The 5-unit code is an example of what is called an even length or constant length code; i.e., one in which the number of signal elements for a character is the same for every character, and the duration of each element is constant. In the 5-unit code, each character consists of a combination of 5-signal elements, and each element may consist of either of two basic signaling conditions (marking or spacing). Thus, a total of  $2^5$  or 32 combinations of the signal elements is possible with this arrangement.

The 32 possible combinations available from the 5-unit code are insufficient to handle the alphabet and numbers, since 26 combinations are required for the letters of the English alphabet alone. This leaves only six combinations for numerals, symbols, or nonprinting functions. This is obviously

inadequate. It was therefore necessary to adopt a plan to enable a larger number of characters to be included, and this was done as follows. Two of the 32 combinations are used as shift-signals, which permit the remaining code combinations in the first case to be used as letters, and in the second case, the combinations are used for numerals, punctuation signs, etc. The shift-signals are often referred to as case-shift signals; i.e., one case is a letter-shift, and the other a figure-shift. When a letter-shift is transmitted, it sets the receiving instrument in a condition to recognize any signal combination subsequently received to be recorded in the letter case, until a figure-shift is received. Then the receiving instrument sets itself in a condition to record any subsequent signal combinations received in the figure case. That is, the interpretation of a signal combination is determined by the previous shift-signal. The use

of this plan enables 30 of the available 32 combinations to have two meanings.

### Eight-Level ASCII Teletypewriter Code

The eight-level ASCII (American Standard Code for Information Interchange) code contains 10 bauds (or bits, a more commonly used term) per character. These are the start bit, seven intelligence bits, a parity bit, and a stop bit. The start, stop and intelligence bits perform the same function as they do in the five-level code. The PARITY (even) bit is a check bit used to ensure an even number of marking bits are in each character transmitted. The example of the letters "R" and "Y" shown in figure 5-15, utilizing the 8-level ASCII code illustrates the parity bit usage. You will notice the letter "R" contains three marking intelligence bits and a marking parity bit, whereas the letter "Y" contains four marking intelligence bits and a spacing parity bit. Thus both characters are ensured even parity as required for military digital data processing equipment usage. The eight-level ASCII code table presented in figure 5-16 provides a cross reference from the binary intelligence bits to the letters/functions they represent. The seven intelligence bit character representation with b7 the high order bit (binomially) and b1 the low order bit, is shown below. EXAMPLE: The bit representation for the character "K", positioned in column 4 row 11, is:

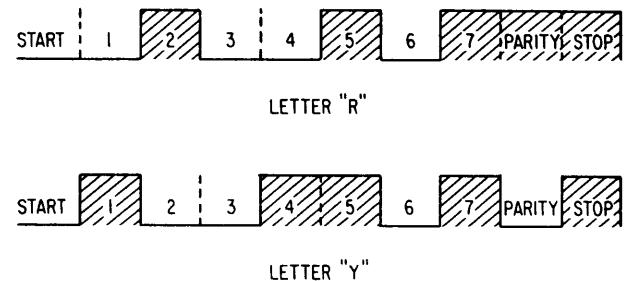
b7	b6	b5	b4	b3	b2	b1
1	Ø	Ø	1	Ø	1	1

The decimal equivalent of the binary number formed by bits b7, b6 and b5, collectively, forms the column number, and decimal equivalent of the binary number formed by bits b4, b3, b2, and b1, collectively, forms the row number.

The utilization of 7 intelligence bits allows 128 possible character combinations.

### MODES OF OPERATION

There are two basic modes of teletypewriter operation: nonsynchronous (start-stop) and synchronous. The most common mode of



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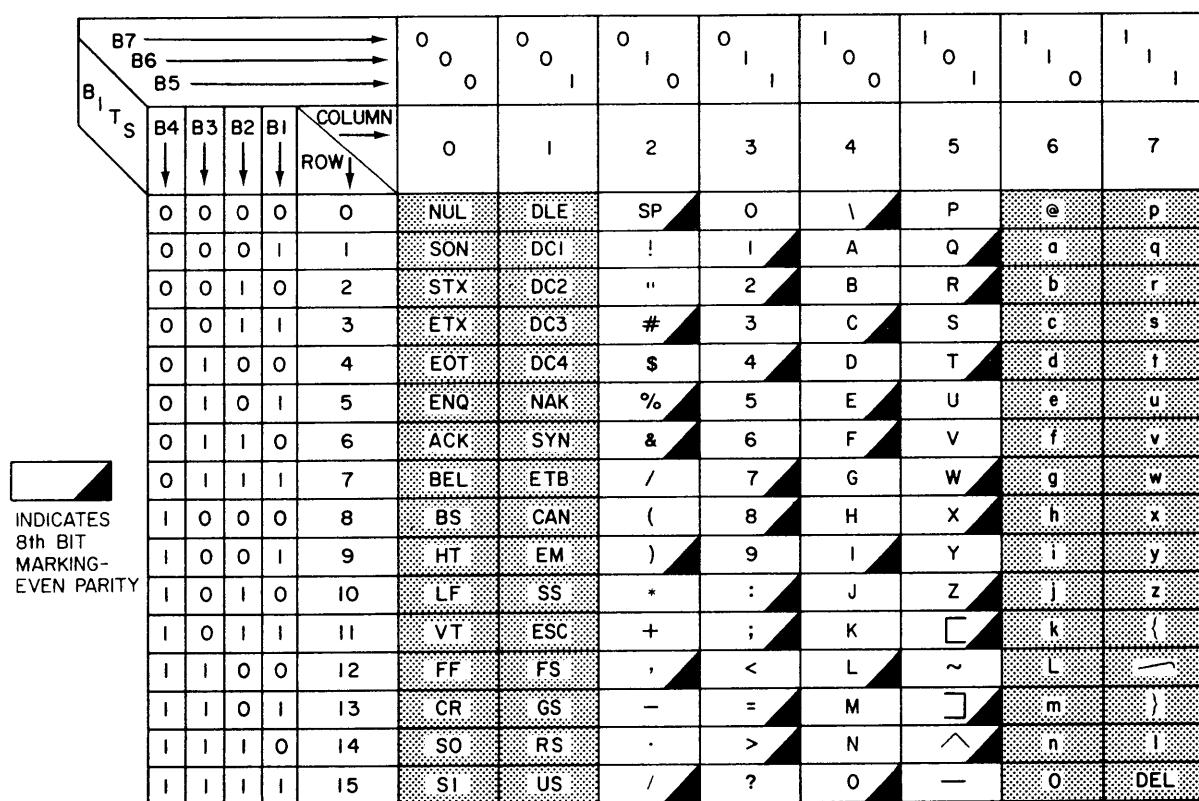
Figure 5-15.—Representation of Characters "R" and "Y" Using Even Parity 8-Level ASCII Military Code.

teletypewriter operation is the start-stop mode. Synchronous operation is used more in high-speed data systems.

In the start-stop mode of operation the receiving device is allowed to run for only one character and is then stopped to await the reception of a start signal indicating that the next character is about to start. In this manner any difference in speed between the transmitting and receiving devices can accumulate only during the duration of one character. However, there is a penalty to pay for this advantage. The length of each character must be increased to include an element to start the receiving device and another added to stop it.

The start element precedes the first code (intelligence) element and is always a space signal. Its purpose is to start the receiving machine. The stop element follows the last code element and is always a mark signal. Its purpose is to stop the receiving machine in preparation for receiving the next character. The start element must be equal to at least one element of the code. The standard mode uses a stop element 1.42 times the length of one code element. It is common practice to refer to a code element as a unit and the duration of a unit as the unit interval.

The length of time required to transmit the entire character is called the character interval. Character interval becomes very important in some transmissions due to certain items of equipment being "character length conscious" or "code conscious." Stop unit intervals of various lengths are used or produced by various



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B <sub>1</sub>	T	S	ROW					0 1 2 3 4 5 6 7						
0 0 0 0 0 0 0	NUL	DLE	SP	0	1	P	@							
0 0 0 0 1 1	SON	DC1	!	1	A	Q	a							
0 0 0 1 0 2	STX	DC2	"	2	B	R	b							
0 0 0 1 1 3	ETX	DC3	#	3	C	S	c							
0 0 1 0 0 4	EOT	DC4	\$	4	D	T	d							
0 0 1 0 1 5	ENQ	NAK	%	5	E	U	e							
0 0 1 1 0 6	ACK	SYN	&	6	F	V	f							
0 0 1 1 1 7	BEL	ETB	/	7	G	W	g							
0 0 1 1 0 8	BS	CAN	(	8	H	X	h							
0 0 1 1 1 9	HT	EM	)	9	I	Y	i							
0 0 1 1 0 10	LF	SS	*	:	J	Z	j							
0 0 1 1 1 11	VT	ESC	+	;	K	~	k							
0 0 1 1 0 12	FF	FS	,	<	L	~	l							
0 0 1 1 1 13	CR	GS	-	=	M	^	m							
0 0 1 1 0 14	SO	RS	.	>	N	^	n							
0 0 1 1 1 15	SI	US	/	?	O	—	o							

NOTE: THE UNSHADED AREAS INDICATE THE PRINTABLE CHARACTERS

31.129

Figure 5-16.—American Standard Code for Information Interchange (ASCII) for Military Use.

equipment, such as 1.0, 1.27, 1.5, 1.96, 2.0, etc. Basically the only difference between them is the length of time required to transmit one character.

Synchronous teletypewriter operation, as opposed to start-stop operation, does not in all cases have to rely upon elements of the transmitted character to maintain proper position in relation to the receiving device. External timing signals may be used, allowing the start and stop elements to be discarded. Then only the elements necessary to convey a character, (and in some cases a reference element,) need to be transmitted.

Synchronous systems have certain advantages over start-stop systems. The amount of time taken to transmit stop and start

elements is made available for information transmission rather than for synchronizing purposes. Only the intelligence elements are transmitted. In start-stop signaling the ability of the receiving device to select the proper line signal condition is dependent upon interference to the start-stop arrival. This means that if the stop to start transition arrives before it should, all subsequent selection positions in that character will appear earlier in time in each code element. A synchronous system, therefore, has a higher capability to accept distorted signals than does a start-stop system.

#### MODULATION RATE

There are several methods of referring to teletypewriter modulation rates or signaling

speeds. These include baud, bits per second (BPS) and words per minute (WPM). Baud is the only one that is technically accurate without using additional qualifying terms. The others are either approximations, or require explanation.

The word baud by definition is a unit of modulation rate. It is sometimes used to refer to a signal element but this reference is technically incorrect. Baud rate is the reciprocal of the time in seconds of the shortest signal element. Hence, to find the modulation rate of a signal in bauds, the figure 1 is divided by the time duration of the shortest unit interval present in the signal. For example, 22 milliseconds (.022) is the time interval of the shortest unit in the 5-unit code of 60 words per minute. To find the number of bauds corresponding to 60 WPM, we divide 1 by .022. Rounding off the results of our division, we arrive at the figure 45.5, which is the baud equivalent of 60 WPM. Each increase in WPM will correspondingly decrease the signal unit time interval. (The Defense Communications System standard speed for teletype operation is 100 WPM.)

Words per minute is used only when speaking in general terms for an approximation of speed. The term 100 WPM means that 100 5-letter words with a space between them can be transmitted in a 60 second period. However, it is possible to obtain this nominal words per minute rate in several systems by varying either modulation rate or the individual character interval (length). For this reason, the modulation rate (baud) method of reference rather than words per minute is used.

Formulas for baud and WPM are as follows:

$$\text{Baud} = \frac{1}{\text{Unit interval}}$$

$$\text{WPM} = \frac{\text{Baud}}{\text{Unit code} \times 0.1}$$

The term "bit" is a contraction of the words "binary digit." In binary signals, a bit is equivalent to a signal element. As a result of the influence of computer and data processing upon

our language, modulation rate is sometimes expressed as "bits per second" (BPS). When it is expressly understood that all signal elements being transmitted are of equal length, then the modulation rate expressed in bits per second is the same as modulation rate expressed in baud.

## D.C. CIRCUITS

It has been pointed out that the two conditions, mark and space, may be represented by any convenient means. The two most common are neutral operation, in which current flow represents the mark and no current flow represents the space, and polar operation, in which current impulses of one polarity represent mark and impulses of the opposite polarity of equal magnitude represent the space.

Neutral circuits make use of the presence or absence of current flow to convey information. These circuits use 20 milliamperes (ma) (or in some cases 60 ma) as the line current value. A neutral teletypewriter circuit is composed of a transmitting device, a battery source to supply current, a variable resistor to control the amount of current, a receiving device, and a line for the transmission medium.

Polar operation differs from neutral, as information is always present in the system, and is either in a positive or negative condition. A polar teletypewriter circuit is composed of the same items as a neutral circuit plus an additional battery source. The reason for having an extra source of battery is that the standard polar circuit uses positive battery for mark and negative battery for space.

The most significant advantage to polar operation is that for all practical purposes it is almost impossible to distort a signal through low line currents, high reactance or random patching of signal circuits or equipment. Another advantage of polar signaling is that a complete loss of current (a reading of ZERO on the milliammeter) indicates line or equipment trouble, whereas the same conditions with neutral signaling may only indicate that a steady space is being transmitted.

## BASIC METHODS OF TELETYPE COMMUNICATION

When two teletypewriters are wire-connected, the exchange of intelligence between them is direct. But when the teletypewriters are not joined by wire, exchange of intelligence is more complex. Direct-current mark and space intervals cannot be sent through the air. The gap between the machines must be bridged by radio. To bridge the gap, a radio transmitter and receiver are needed. The transmitter produces a radiofrequency carrier wave to carry the mark and space intelligence. Also, a device such as a KEYER is needed to change the d.c. pulses from the teletypewriter into corresponding mark and space modulation for the carrier wave in the transmitter. The radio receiver and a CONVERTER are required to change the radio frequency signal back to d.c. pulses.

The Navy uses two basic methods of teletype communication; the tone-modulated method, referred to as audiofrequency tone-shift (AFTS), and the carrier frequency-shift method, referred to as radiofrequency carrier shift (RFCS). The RFCS method is also called frequency-shift keyed (FSK).

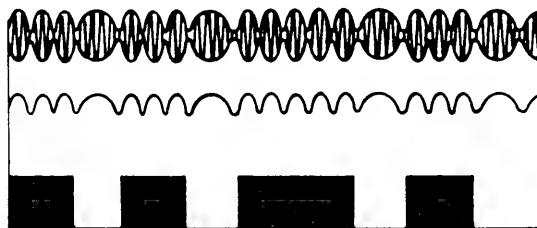
Figure 5-17 shows a modulated carrier wave with audio tone impulses impressed on the radiofrequency carrier wave, with corresponding d.c. mark and space signals.

The RFCS signal can be explained by comparing it to the on-off CW signal. As CW signals are of essentially constant frequency, there is no variation along the frequency axis (fig. 5-18A). The complete intelligence is carried as variations in the signal amplitude. Figure 5-18B shows the same signal as a shift in frequency between the mark and space.

### TONE-MODULATED METHOD

Tone-Modulated (AFTS) Method uses the process of amplitude modulation to change the d.c. mark and space impulses into audio electrical impulses.

Conversion to the audio tones is accomplished by an audio oscillator in the tone



1.226

Figure 5-17.—Modulated Carrier Wave with Audio Tone for Mark and Space.

converter (such as the AN/SGC-1A) which operates at 700 Hertz (Hz) for a mark impulse and at 500 Hz for a space impulse. This may be reversed subsequent to the printing of this manual. The rapid varying of the tone according to the characters transmitted from the teletype equipment amplitude modulates the carrier wave in the transmitter. The receiver receives the modulated signal and separates the audio signal from the carrier. This process of separating the modulated signal is known as detection or demodulation. A basic tone-modulated system is shown in figure 5-19.

### Tone Converter AN/SGC-1A

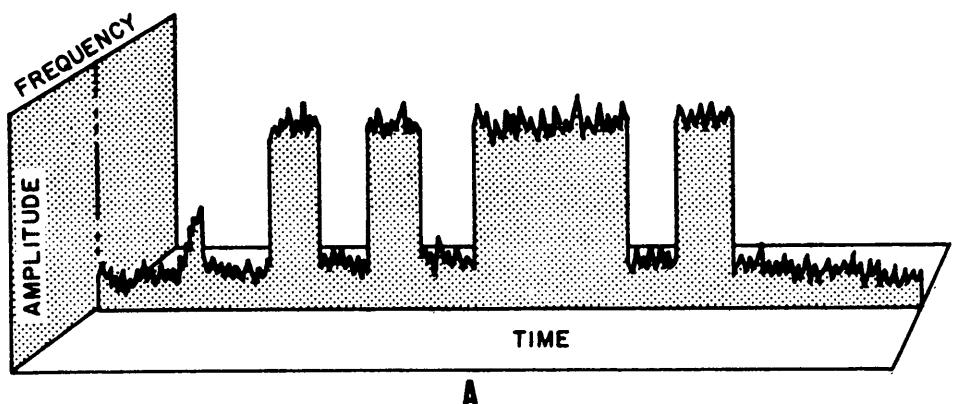
Tone modulation employs a tone converter, one type of which is included in Radio Teletype Terminal Set AN/SGC-1A (The CV-2460-SGC is replacing this set in some installations.) As illustrated at the center of figure 5-20. Other associated equipment includes a radio receiver and transfer panel, a radiophone transmitter and transfer panel, and a teletypewriter and panel. The blocks indicate that any suitable standard Navy components may be used.

In tone modulation transmission, the teletypewriter pulses are converted into corresponding audio tones, which amplitude modulate the voice-frequency transmitter. Conversion of the audio tones is accomplished by an audio oscillator in the tone converter, which operates at 700 Hz when the teletype loop is in a closed-circuit (mark) condition and at 500 Hz when the loop is in an open-circuit (space) condition.

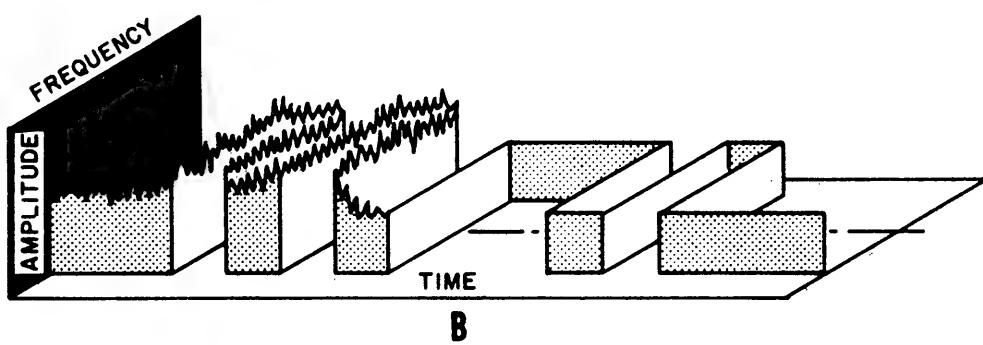
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Figure 5-18.—CW and RFCS Telegraph Signals.

An internal relay in the tone converter closes a control line to the radio transmitter, which places the unit on the air when the operator begins typing a message. The control line remains closed until after the message has been transmitted.

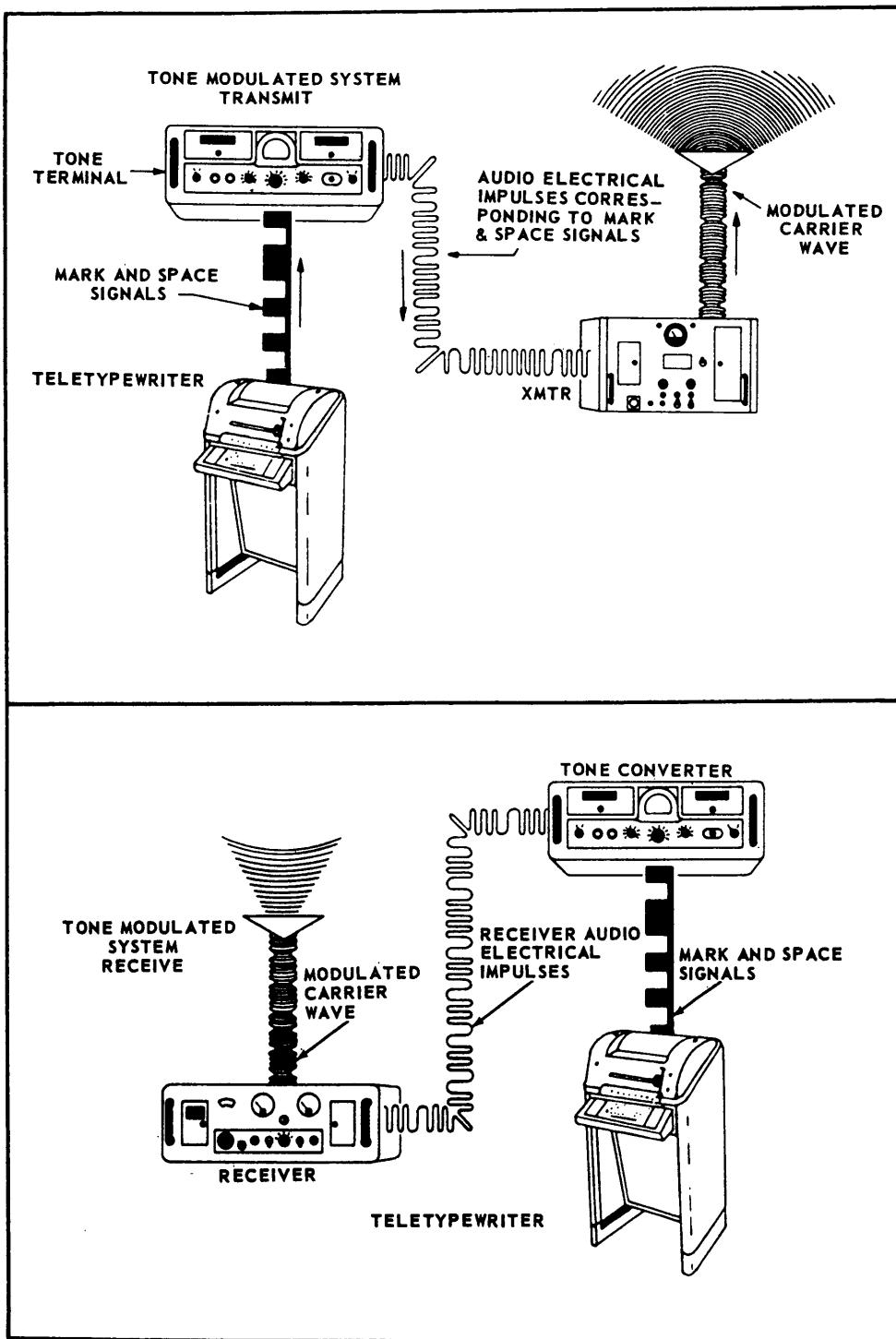
When receiving messages, the tone converter accepts the mark and space tones coming in from an associated radio receiver and converts the intelligence of the tones into signals suitable to operate the make and break contacts of a relay connected in the local teletypewriter DC loop circuit. This action causes the local teletypewriter to print in unison with the mark and space signals from the distant teletypewriter.

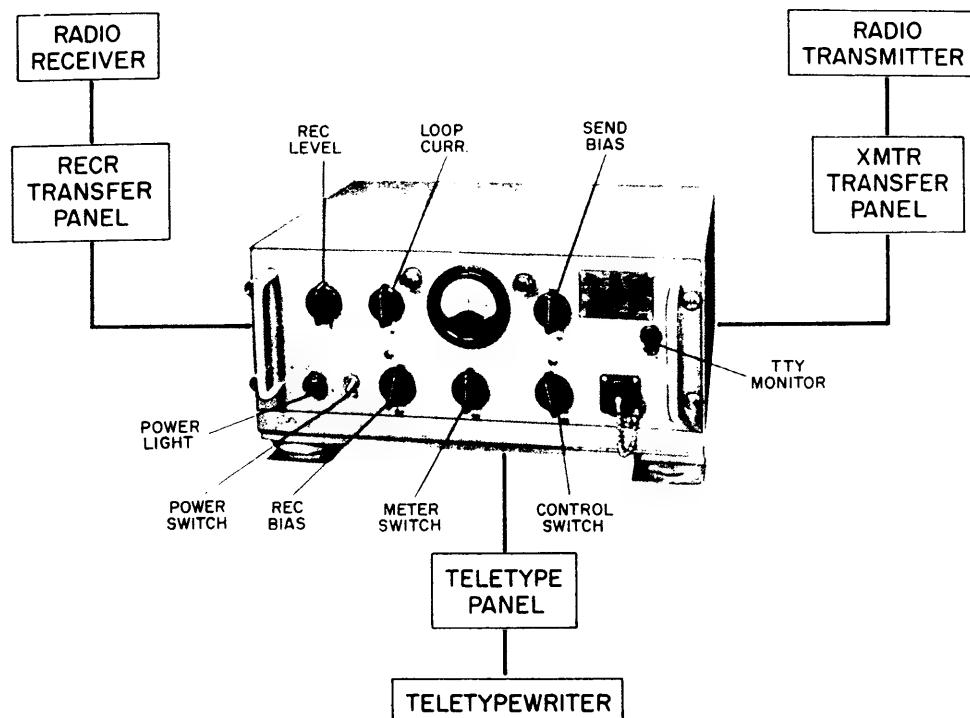
The receive level calibrated attenuator is located at the upper left side of the front panel

on the tone converter. This control permits adjustment of the level of the incoming tone signals from the receiver. The loop current rheostat is next to the receive level control, and is adjusted when the teletype loop is in the mark, or closed circuit condition. A zero-center meter indicator is located at the upper middle portion of the front panel. An associated switch is located directly below the meter. It has several positions to permit measurements to be taken in all the necessary portions of the circuit.

Two indicator lights flank the upper part of the meter. One light indicates the receive condition and the other indicates the transmit condition. Both lights are off when the tone converter is in the standby condition.

The send bias rheostat is located at the right of the meter. This control permits correction of





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Figure 5-20.—Teletype Tone Converter AN/SGC-1A.

any teletype distortion (for example, unequal length of mark and space signals) in the local teletypewriter loop when sending a teletype message.

At the far right is a jack marked, TTY monitor. A test or monitoring teletypewriter may be patched into this jack, thereby placing it in series with all other equipments in the loop.

NOTE: headphones must not be plugged into this jack.

The power indicator light is located at the lower left side of the front panel of the tone converter. The power ON-OFF switch is located next to it.

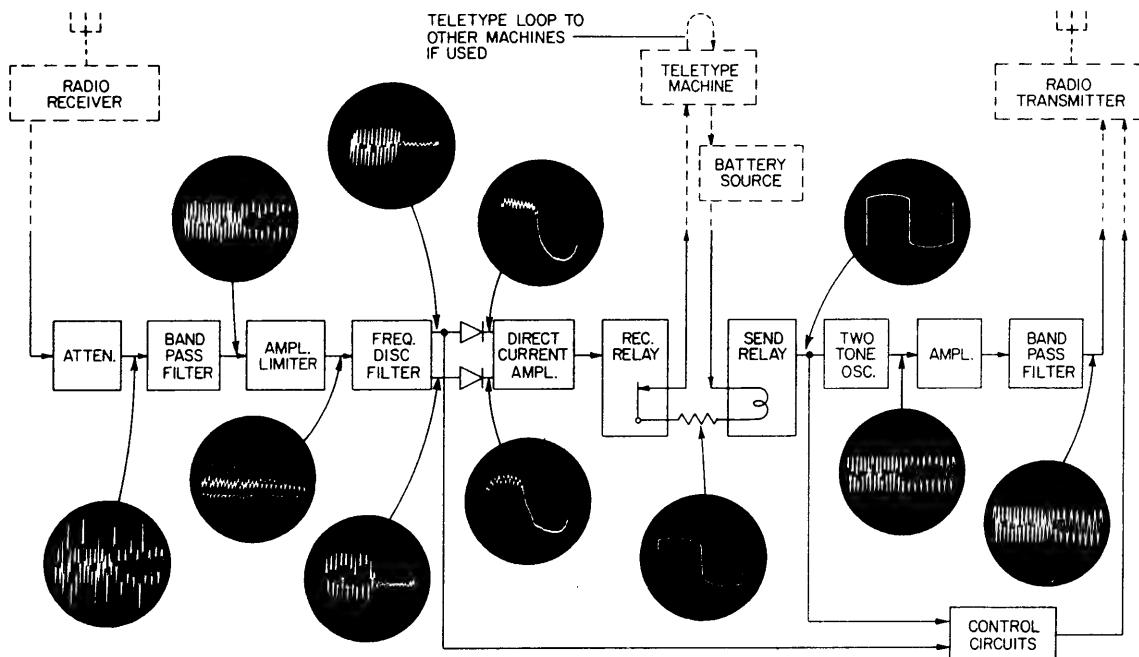
The receive bias potentiometer is located at the right of the power switch. This control enables correction of distortion (unequal length of mark and space tones) in the receiving tone circuit.

The control switch is located at the right of the meter switch. The position of the control

switch determines the function of the tone converter to either receive or to transmit teletype signals.

A 115-volt, 60 Hz convenience outlet is provided at the lower right of the front panel. It bypasses the power switch.

A block diagram of the tone converter is illustrated in figure 5-21. Typical oscilloscope patterns are included. The attenuator is located at the input of the receive circuit to permit adjustment of the level of the incoming 2-tone signal. The bandpass filter passes all frequencies in the band from 400 to 800 Hz and rejects all other frequencies. The amplifier limiter stages have a constant-output level. The frequency discriminator filter selects the fundamental frequencies of 500 Hz and 700 Hz and routes them via separate germanium rectifiers to corresponding d.c. amplifiers (in the d.c. amplifier block) and associated relay coils in the receiver relay block. A 700 Hz signal causes the receive relay to close the teletype d.c. loop, a



1.241

Figure 5-21.—Block Diagram of Tone Converter.

500 Hz signal causes the relay to open the loop. Thus, corresponding mark and space signals are developed in the teletype loop circuit.

In sending, the mark and space signals in the d.c. loop cause the send relay to apply either a d.c. voltage or no d.c. voltage, respectively, to the two-tone oscillator. A mark signal causes the oscillator to operate at 700 Hz; a space signal causes it to operate at 500 Hz.

The output of the oscillator passes through a level-controlling potentiometer (not shown in the diagram) to the amplifier stage. The output of the amplifier passes through a bandpass filter to the radio transmitter.

The control switch is used to change from one operating condition to another or to permit the accomplishment of specific operating or maintenance functions. If it is desired to prevent the sending of a message by the teletypewriter, the control switch may be turned to REC/STDY. Thus, the equipment cannot change

to the transmit condition even though the teletypewriter is operated, but it can receive messages or remain in the standby condition.

In carrying on communications, the equipment should not be operated with the control switch turned to TRS because the equipment is then locked in the transmit condition and cannot receive any message until released by turning the control switch to one of the other two operating positions.

Usually, for half-duplex communication (described below), this switch is set at the AUTO position. In auto condition, operators at two or more stations having this equipment can engage in full communication. After a station has completed sending its message, it is ready for reception of any return message after an automatic three-second time delay. When the switch is in the AUTO position, the tone converter may be in one of three conditions: receiving, transmitting, or standby. When in the

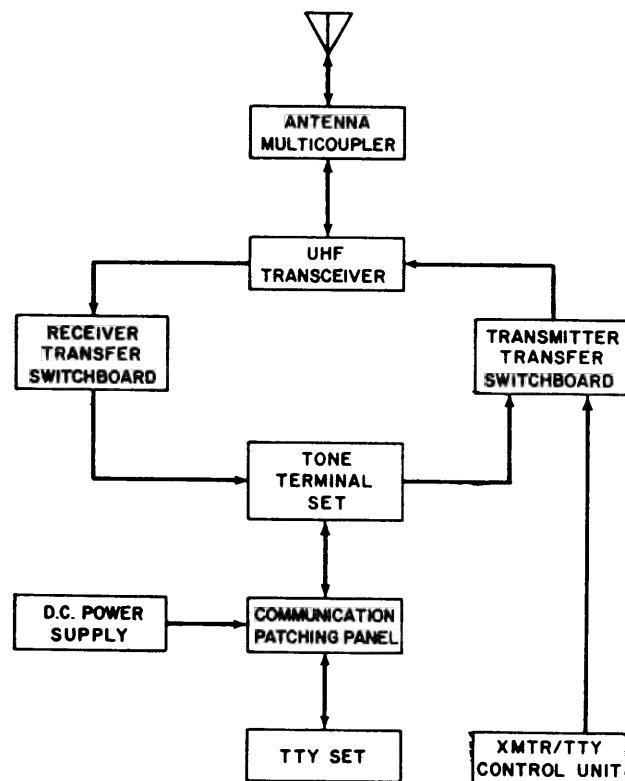
standby condition, the reception of an incoming mark tone causes the control circuit to change to the receiving condition. Following the end of the incoming message, the internal circuits of the equipment shift back to the standby condition. When in this condition the operation of the local teletypewriter causes the circuits to change from standby to the transmit condition. After the last letter of the message is sent, there is a time delay of about three seconds and then the internal equipment circuits shift back to the standby condition. The interlocking functions prevent the equipment from shifting directly from transmit to receive, or vice versa. Thus, an incoming signal will not interrupt an output signal, nor will keying the local teletypewriter, when receiving, cause the circuit to shift to the transmit condition. The control circuits also, when shifted to transmit condition, cause the control contacts of the transmit control relay to the radio transmitter to close, thereby placing the transmitter carrier on the air.

After a station has sent its message, it is ready for reception of any return message following an automatic three-second time delay. Because of the small time delay inherent in the operation of the control circuits of the local and distant terminals the first character transmitted is usually lost. Therefore, the first character typed should be the "letters" key.

#### DUPLEX COMMUNICATION CIRCUIT

A simplified block diagram of a half-duplex (send or receive) UHF, AFTS system is shown in figure 5-22. A half-duplex communication circuit permits unidirectional communications between stations. Communications can be in either direction, but not simultaneously. The term half-duplex is qualified by adding "send only", "receive only", or "send or receive."

A FULL-DUPLEX (or DUPLEX) communication circuit permits uninterrupted exchange of information between stations by using two separate circuits. Each station may transmit and receive simultaneously.



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Figure 5-22.—Half-Duplex AFTS Teletype System.

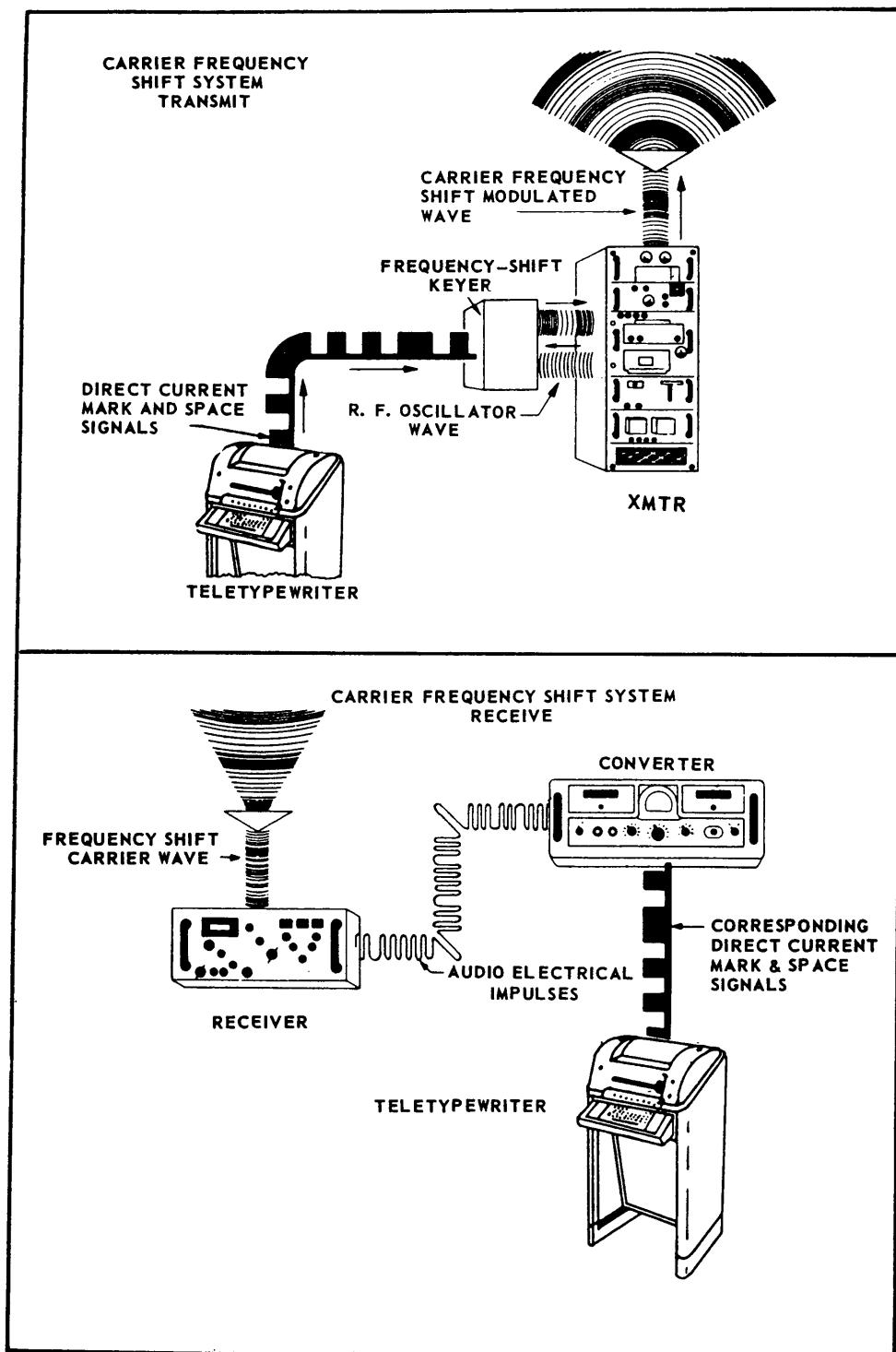
#### Signal Flow

On the transmit side, d.c. signals from the TTY set are fed to the communication patching panel where they are patched to the tone terminal set. The tone terminal set converts the d.c. signals into audio tone-shift signals, which are patched to the transmitter section of the transceiver through the transmitter transfer switchboard. The audio tone-shift signals modulate the RF carrier generated by the transmitter. The RF tone-modulated signals are then radiated by the antenna.

On the receive side, the RF tone modulated signals are received at the antenna and patched via the multicoupler to the receiver section of the transceiver, where demodulation takes place. The resulting audio tone-shift signals are then patched through the receiver transfer switchboard to the tone terminal set, where they are converted back to the d.c. signals. The d.c.

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Figure 5-23.—Basic Carrier Frequency-Shift (RFCs) System.

signals are patched through the communication patching panel to the TTY set.

### CARRIER FREQUENCY—SHIFT METHOD

For Frequency-Shift (RFCS) Method, a keyer in the transmitter provides a source of radiofrequency excitation which can be shifted below or above the assigned frequency corresponding to the mark or space required to transmit the teletype characters. NOTE: In the past U.S. Navy communications equipment has been set up so that the shift above the assigned frequency represented the mark and the shift below the assigned frequency represented the space. For standardization purposes, this is being reversed so that the high frequency represents the space and the low frequency represents the mark. Normally the keyer is adjusted for an 850 Hz spread, 425 Hz above the assigned frequency and 425 Hz below. A spacing impulse will be 425 Hz above the operating frequency, and a marking impulse will appear 425 Hz below. Figure 5-23 illustrates a basic frequency shift system. In modern systems, the keyer is built into the transmitter. Figure 5-24 is a simplified block diagram of a frequency shift receiving system.

In both the tone-modulated method and the carrier frequency-shift method, all

teletypewriter signals pass through the teletypewriter panel that controls the looping current in all the circuits. The teletypewriter panel integrates the tone-modulated and the carrier frequency-shift methods. It provides every possible inter-connection of available teletypewriter equipment; thus, maximum operational flexibility is achieved with the fewest number of circuits and the least amount of equipment.

### Simplex RFCS Teletype

Radiofrequency carrier shift teletype systems are used in the LF to HF bands for long range communications. To reduce fading and interference problems in these bands, the Navy uses two methods of DIVERSITY RECEPTION (fig. 5-25). These methods are SPACE DIVERSITY (fig. 5-25, A) and FREQUENCY DIVERSITY (fig. 5-25,B).

In SPACE DIVERSITY reception (fig. 5-25, A), one signal is transmitted, and this signal is received by two or more receivers. The receiver antennas are separated by a distance greater than one wavelength. The outputs of the receivers are fed into frequency-shift converters which convert the audiofrequency-shift signals into d.c. mark and space signals. The d.c. signals are then fed into a comparator which selects the best mark and space signals for the

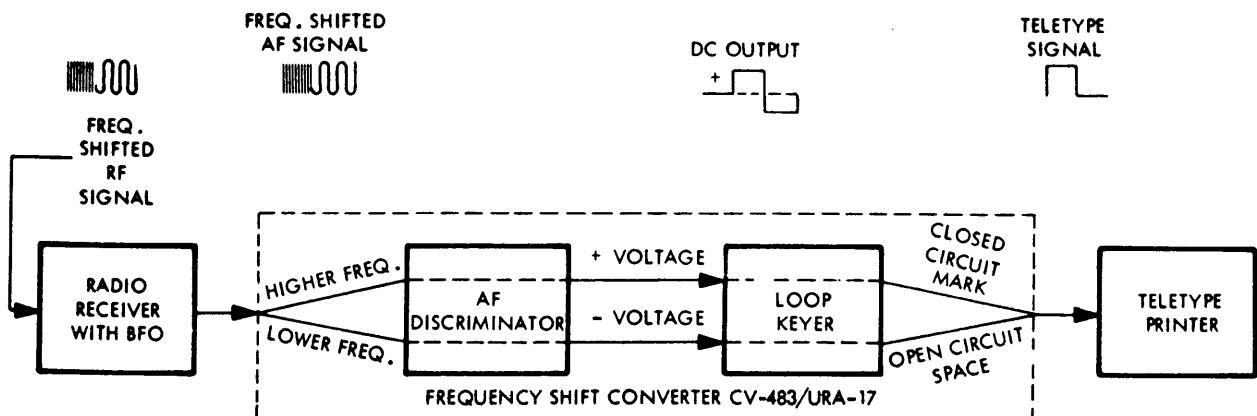


Figure 5-24.—Frequency Shift Receiving System Simplified Block Diagram.

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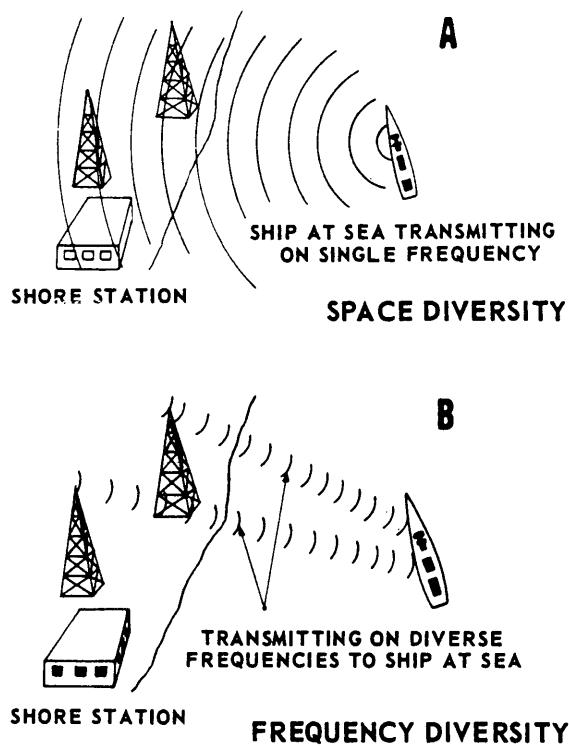
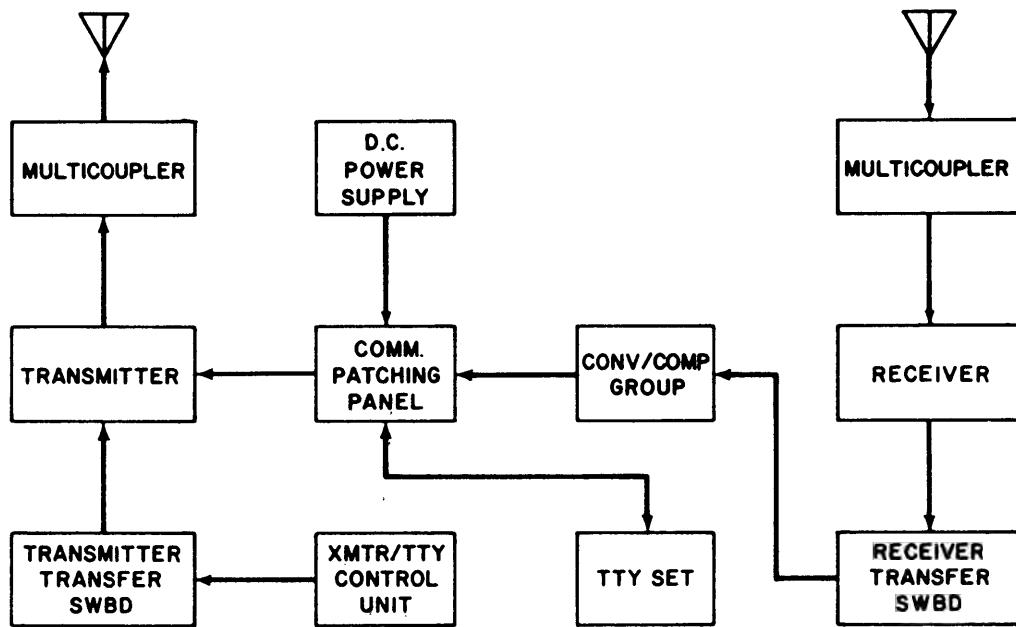


Figure 5-25.—Diversity Reception. 70.10

teletypewriter. Because of required spacing between the receiver antennas, space diversity is mostly limited to shore stations.

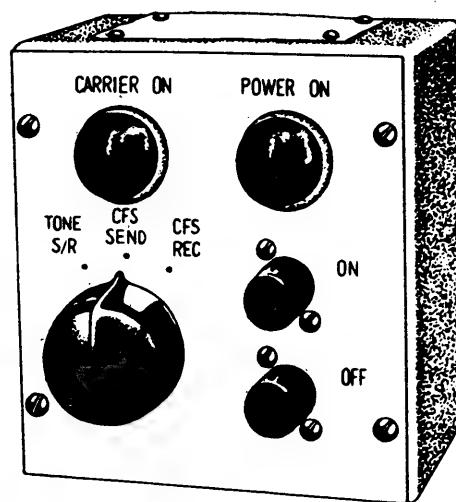
In FREQUENCY DIVERSITY reception (fig. 5-25, B), two or more signals carrying the same intelligence are transmitted on different frequencies. The signals are received by receivers and processed in the same manner as for space diversity to operate teletype equipment from the best of the transmitted signals. This form of frequency diversity is known as RF DIVERSITY. Another form of frequency diversity called AF diversity or tone diversity is used with multichannel broadcasts. This is discussed later in this manual.

A simplified block diagram of a simplex MF/HF RFCS teletype system is shown in figure 5-26. A SIMPLEX communication circuit consists of a single channel over which two or more stations may communicate. Each station may transmit and receive, but not simultaneously. On the transmit side (fig. 5-26), the teletypewriter (TTY) set keyboard or transmitter distributor applies the d.c. teletype signals to the communication patch panel where they are patched to the transmitter. The d.c.



162.133

Figure 5-26.—Simplex RFCS Teletype System.



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Figure 5-27.—Transmitter/TTY Control Unit.

mark and space signals shift the frequency of the RF carrier generated by the transmitter as explained previously.

On the receive side, the RF frequency-shift signal is received and demodulated by the receiver, resulting in an audio signal which shifts 850 Hz between marks and spaces. This audio-frequency-shift signal is fed to a converter in the converter/comparator group where it is

converted into the original d.c. mark and space signals. The d.c. mark and space signals are then patched through the communication patch panel to the TTY set.

### TRANSMITTER/TTY CONTROL

The transmitter/TTY control unit (fig. 5-27) is mounted close to the teletype keyboard, and permits remote control of the transmitter. It has a transmitter power on-off switch, a power-on indicator lamp, a carrier-on indicator lamp, and a three position rotary selector switch. For RFCS operation, the operator sets the switch to CFS SEND for transmitting and to CFS REC for receiving. The TONE S/R position is used for both transmitting and receiving AFTS signals.

### CONVERTER/COMPARATOR GROUP

The converter/comparator group is used with receivers in either space or frequency diversity operation. When diversity operation is not required, each converter can be used separately with a single receiver. A representative converter/comparator group is shown in figure 5-28.

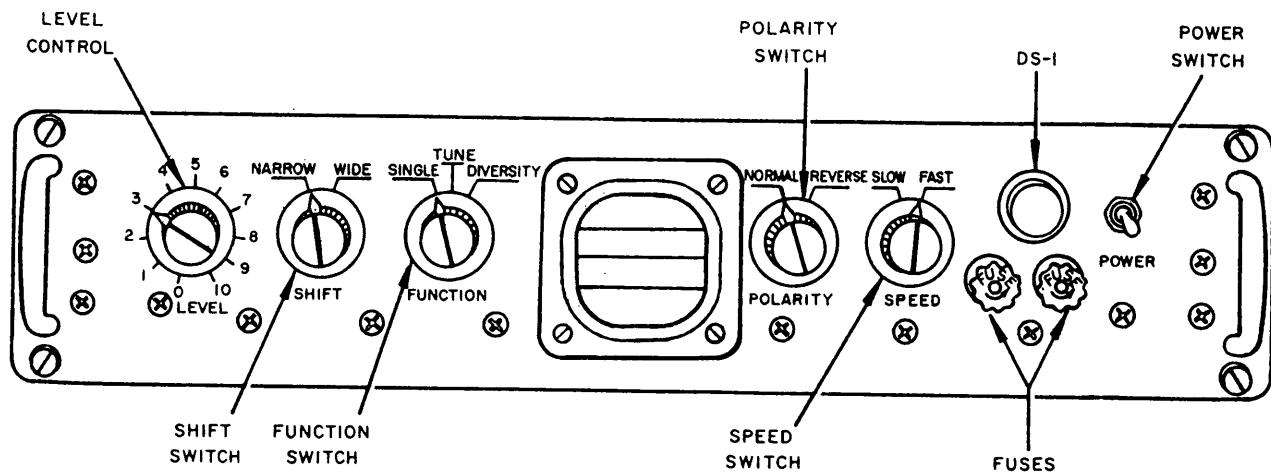


Figure 5-28.—Frequency-Shift Converter CV-483/URA-17 Front Panel Controls.

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Each converter (fig. 5-28) has its own comparator circuitry. This built in design feature results in a considerable reduction in size from older units where the comparator is located in a separate chassis. A further reduction in size is achieved by the use of semiconductors and printed circuit boards.

The simplified block diagram (fig. 5-24) shows the basic function of converting the frequency-shift RF signal into a signal for controlling the d.c. loop of the TTY. The frequency shifts of the AF output from the receiver are converted into d.c. pulses by the AF discriminator. The d.c. pulses are fed into the loop keyer which opens and closes the d.c. loop of the TTY according to the mark and space characters received.

The comparator section of the converter/comparator functions to compare the strength of the signals from the receivers in diversity operation. Signals from each converter are fed into a comparator circuit which compares the signals and allows only the stronger signal to be fed to the communication patching panel for patching to the TTY.

### MULTIPLEXING

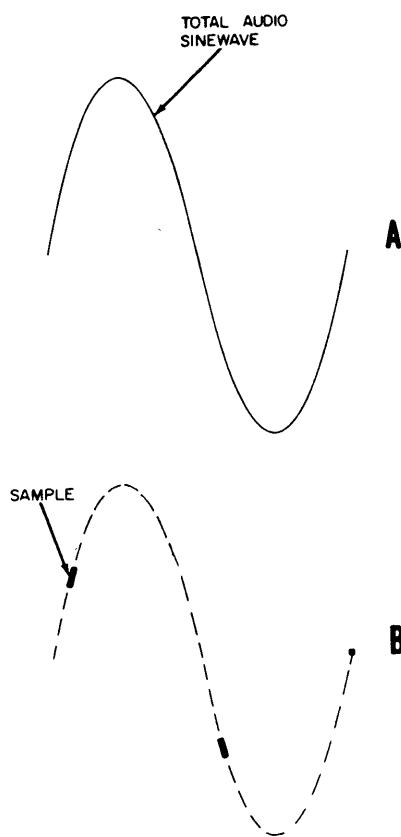
The number of communications networks in operation per unit of time throughout any given area is constantly increasing. In the past, each network has been required to operate on a different radiofrequency. As a result, all of the RF spectrum has become highly congested. The maximum permissible number of intelligible transmissions taking place in the radiofrequency spectrum per unit of time has been increased through the use of multiplexing. Multiplexing involves the simultaneous transmission of several intelligible signals on the same frequency during the same period of time. Either of two methods of multiplexing may be used. These are time-division and frequency-division multiplexing, of which, frequency-division multiplexing is the most common method used by the Navy.

The information which follows will present only the basic principles relating to

multiplexing. For more information on multiplexing it is recommended that the technician study *Radio Wave Modulation and Signal Multiplexing*, NSGTP 68311.

### TIME-DIVISION MULTIPLEXING

With AM voice and tone communications, it is desired to transmit and receive the full 360 degrees of each sine wave (fig. 5-29, A). However, an audio signal may be transmitted and received satisfactorily by periodically sampling the signal. The result of the sampling process yields a received signal such as that shown in figure 5-29B. Although there is no limit to maximum number of samples that may be made, an approximate minimum of 2.4 samples per cycle of audio will give satisfactory results. In practical systems, 2.4 samples per



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Figure 5-29.—Components of a Sampled Sine Wave.

cycle are usually taken. This concept of sampling forms the basis for time-division multiplex operation.

Figure 5-30, A illustrates in a highly simplified form the basic principle of time-division multiplexing. Assume that a 3,000 Hz tone is applied to each of the six channels in the transmitter. Assume also that the rotating switch turns fast enough to sample, in turn, each of the six channels 2.4 times during each cycle of the 3,000 Hz tone. The speed of rotation of the switch must then be  $2.4 \times 3,000$  or 7,200 rotations per second.

If the transmitter and receiver switches are synchronized, the signals will be fed in the proper sequence to the receiver channels. The transmitted samples from transmitter channel 1 will be fed to receiver channel 1. Thus, in the time-division method of multiplexing, many channels of audio are combined (with time spacing between components of the separate channels) to form a single output (multiplexed) chain. The chain is transmitted (via wire or radio facilities) to distant demultiplexing receivers, each of which functions to select only the information pertaining to its particular channel.

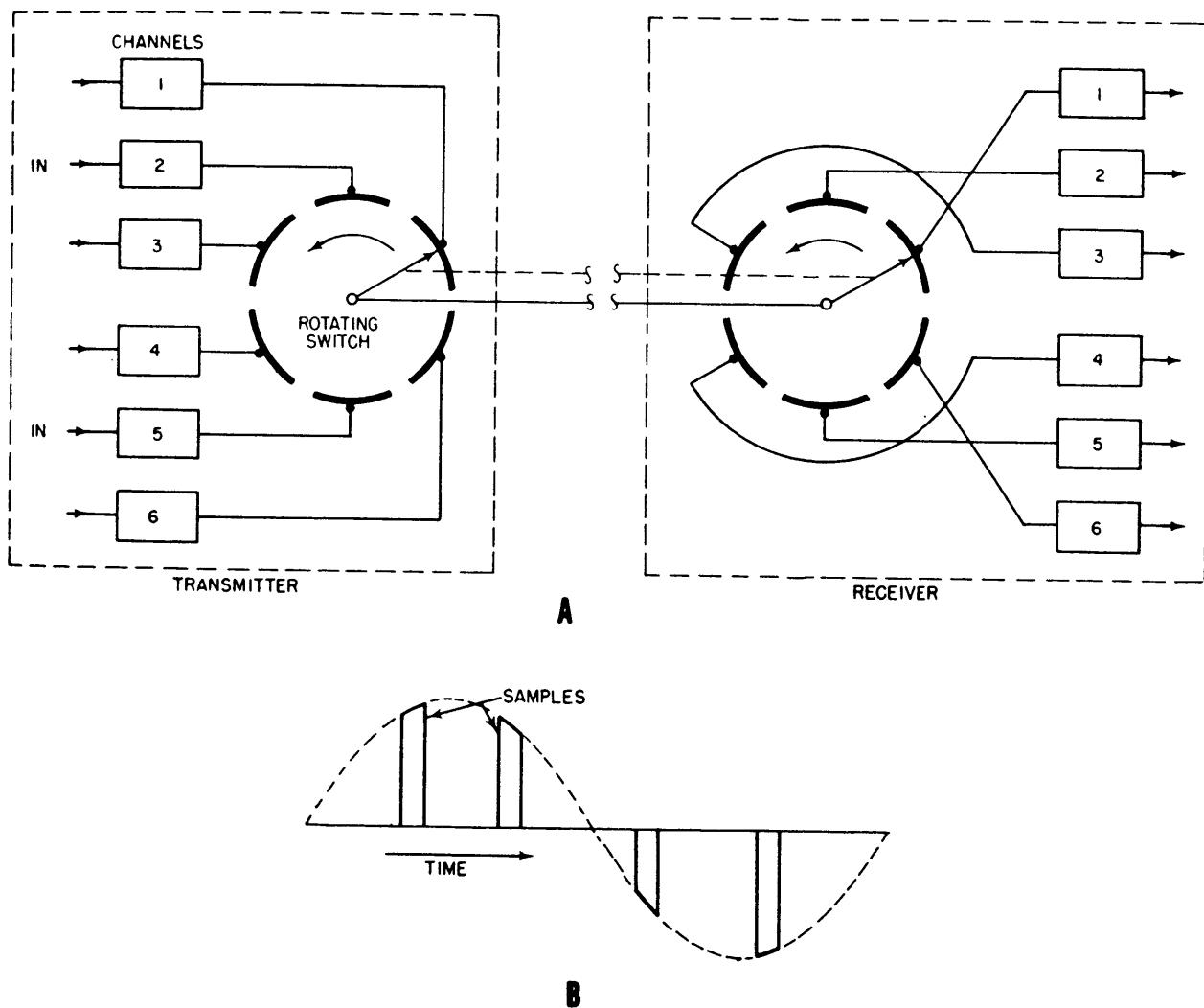


Figure 5-30.—Basic Principle of Time-Division Multiplexing.

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A mechanical system is shown here for the sake of simplicity. In actual operation, no mechanical switching arrangement will provide the high speed of switching used in practical multiplexing systems. For this reason, electronic switching is used.

A sine wave sampled four times for each channel is illustrated in figure 5-30, B. In an actual transmission, segments from the wave-forms in all of the channels will be interspersed with these four segments on a time-sharing basis. In other words, only one segment can be transmitted at a time; and the segments are taken in sequence from the wave-forms existing in the six channels.

More than six channels (perhaps 24 or more) may be used. However, as the number of channels increases the sampling rate must be increased (28,800 Hz for 24 channels as opposed to 7,200 Hz for 6 channels using the above example). In addition the width of each segment must be proportionately reduced. Decreasing the pulse width will decrease the minimum required rise time and increase the required bandwidth even more because of the increase in the number of harmonics contained in the sharper leading edge of the pulse.

The bandwidth is also affected by the shape of the sampling pulse and the method of varying the pulse to carry the modulation. Commonly used methods of time division multiplexing include pulse amplitude modulation (PAM), pulse width or duration modulation (PWM or PDM), and pulse position modulation (PPM). Pulse amplitude modulation is the type illustrated in figure 5-30.

In time-division multiplexing, to use time in the most efficient manner, the bandwidth necessary to transmit  $n$  channels would be only slightly wider than  $n$  times that necessary for one channel. However to prevent crosstalk, etc., the minimum bandwidth is not generally utilized.

In time-division multiplexing methods, either the amplitude or the frequency of the transmitter signals (samples) from the respective

channels may be varied to affect modulation. In each case, a modulating pulse is made to vary with respect to the amplitude of the audio signal.

The sampling process allows modulating pulses at a fixed rate to be introduced to the RF transmitter carrier, or to the wire cable equipments. No less than 2.4 of these samples must be transmitted for each cycle of the audio in order to produce an intelligible signal at the reproducer.

If the rate of sampling throughout the multiplex system is adjusted to 9.3 kHz then the maximum allowable audiofrequency  $= \frac{9300}{2.4} = 3875$  Hz. This frequency represents the highest audiofrequency that may be used. In practice, for better fidelity translation it is desirable to provide more than the minimum number of samples per second. For this reason, filters would be employed in this system to eliminate frequencies above about 3000 Hz.

### Block Diagram

Sampling the audio signal of several channels through the use of electronic switching can be accomplished in several ways. A block diagram analysis of one method used in time-division multiplex is shown in figure 5-31. In this system, it is first necessary to develop a voltage that varies linearly with time to establish the basis for time-division multiplex. A bootstrap type sawtooth (time base) generator, which uses a linearity stage to improve both voltage output and voltage linearity is used for this purpose.

The sawtooth generator output voltage (through the rise time) is applied to the grid of a normally cutoff sawtooth selector stage (V4). Conduction of this stage occurs when the sawtooth amplitude reaches a potential slightly less than the bias voltage on the selector. When the sawtooth voltage becomes sufficiently high to cause conduction of the selector, a trigger pulse is produced at the grid of a one-shot multivibrator (V5 and V6). The multivibrator

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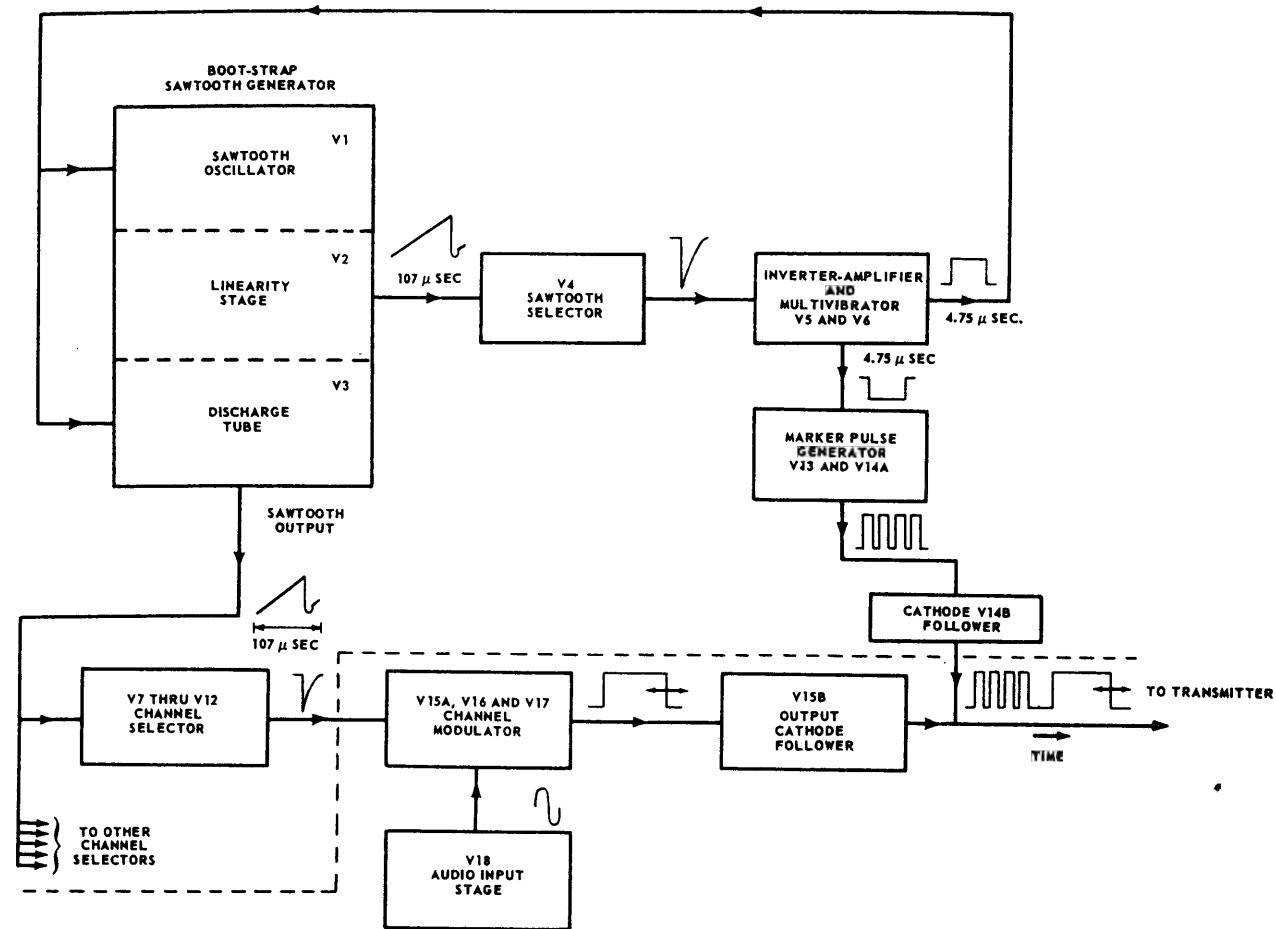


Figure 5-31.—Time-Division Multiplex Block Diagram.

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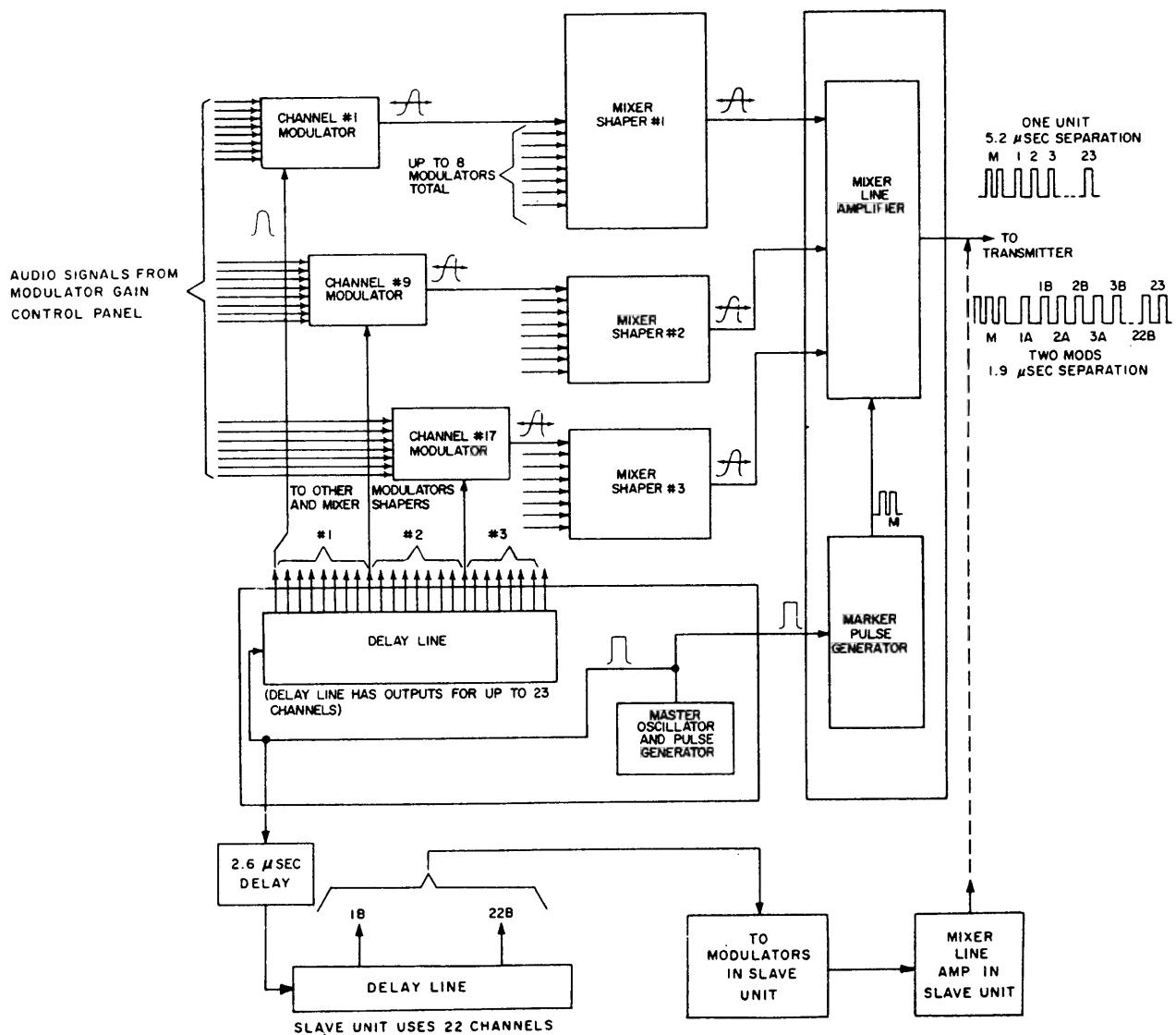
output is returned along dual paths to the sawtooth generator oscillator and discharge tube to cause the sawtooth flyback. The amplitude of the sawtooth may be varied by manually varying the bias on the selector.

The sawtooth generator output waveform is fed along paralleled paths to the channel selectors (V7 through V12) one of which is contained in each channel of the multiplex system. Each individual selector is biased at a different level so that each is energized at a different time by the sawtooth voltage.

As each channel selector is energized, it feeds a pulse to its respective channel modulator, causing this circuit to produce a

channel pulse. The channel pulse thus produced (for this channel alone) is then modulated in accordance with the type of pulse modulation used by the incoming audio.

Included in the transmitter output is a marker pulse(s) (sometimes called a sync group). The primary purpose of the marker pulses is to act as a synchronizing voltage between the receiving and transmitting multiplex terminals. These pulses may be of any form but are usually of a nature that makes them easily distinguishable from the modulation pulses at the receiving terminal of the multiplex system. The marker pulse (or pulses), along with the total modulation pulses from each channel (in



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Figure 5-32.—Block Diagram of Multiplex Modulation Circuits.

time) presented to the transmitter carrier during one complete cycle of the sawtooth waveform, constitutes a video frame.

The marker pulses are formed by the negative gate from the multivibrator (occurring at the same time as the positive pulse that produces the sawtooth decay) which gates an oscillator (marker pulse generator) circuit to cause the generation of the marker pulses. In figure 5-31, four  $.5\ \mu\text{s}$  pulses spaced  $0.8\ \mu\text{s}$  apart are produced. These pulses are passed through a

cathode follower (impedance matching) circuit to the transmitter. Both marker pulses and channel pulses are coupled along the same line to the transmitter, because each of the pulses is added to the video frame at a different time interval.

#### Function of Delay Line

In any time-division multiplex system, the development of an accurate method of

energizing the various channels at a given time is of utmost importance. The method must employ some type of highly stabilized master oscillator. In the system just discussed, a triggered bootstrap sawtooth oscillator was used in both the multiplex and demultiplex equipments. A crystal-controlled oscillator would serve equally as well.

A block diagram of a time-division multiplex system using a crystal-controlled master oscillator and delay line is shown in figure 5-32. The oscillator generates an 8 kHz sine wave, which is clipped by the pulse generator circuit to produce a square wave output. The oscillator frequency (8 kHz) is the frame or base frequency of the multiplex system. This output is coupled along dual paths to a marker pulse generator, and to an artificial delay line.

The artificial delay line comprises 24 sections of pi-connected inductors and

capacitors, each of which introduces a delay (5.2  $\mu$ s) to the passage of the pulse along the line. A connection is made to a modulator channel from each section of the delay line. Thus, 23 channel modulators can be activated at time intervals of 5.2  $\mu$ s (fig. 5-33, A) by the trigger pulses from the line. The presence of the controlling pulse enables the modulator to generate one channel pulse per frame (8,000 per second). The frequency of the audio signal applied to the modulator varies the position of the pulse (as indicated by the double-headed arrow through the waveform) and this comprises the signal intelligence for the channel. Thus the 24 section delay produced up to 23 channels, and during the 24th part of the frame interval a double-pulsed marker (three pulses in latest equipment) is produced for synchronizing the multiplex system.

To minimize crosstalk, the modulators are arranged in three groups of eight. The output of

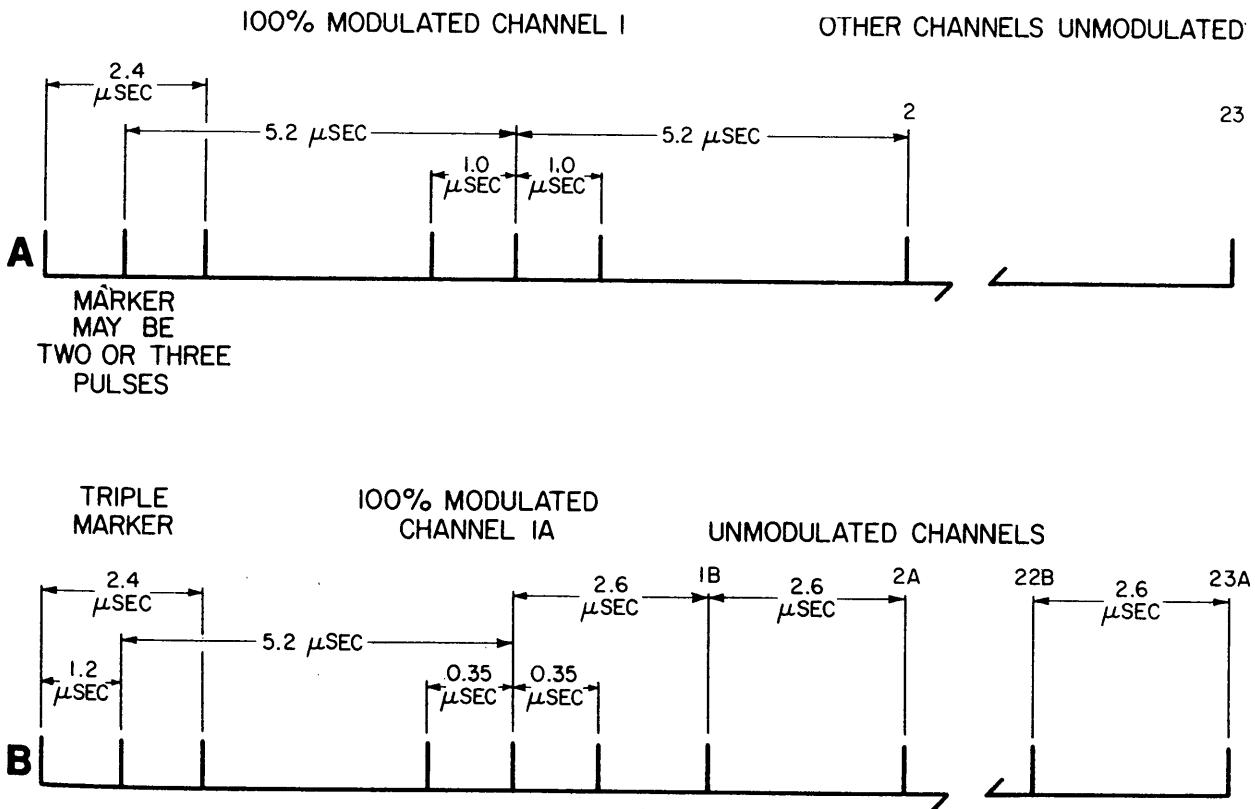


Figure 5-33.—Pulse Relationship, 23 Channel and 45 Channel.

each group of eight modulators is combined in the mixer shaper, which shapes each modulator output into a narrow pulse. The output of each of the mixer-shaper stages is applied to a single mixer line amplifier, which combines all the channel pulses and marker pulses into a single video frame. The mixer line amplifier output is applied to the RF transmitter circuits.

The pulse train input to the demodulator (fig. 5-34) comprises the marker, and up to 23-pulse position (time) modulated channel pulses. The signals are shaped in a clipper-shaper stage and applied to the marker-separator.

The marker-separator circuit extracts (detects) the double-pulsed marker and converts

it to a suitable square waveform, which is fed to a 24-section delay line. This delay line is identical to that employed in the multiplex circuits.

The line produces the controlling pulses (properly spaced in time sequence) for activating the individual channel demodulators. The first output pulse is delayed 5.2  $\mu$ s from the input pulse. Each of the remaining pulses is delayed successively 5.2  $\mu$ s from the preceding pulse.

The first 23 pulses from the delay line form the control or deblocking pulses for the 23 demodulators. Each demodulator employs a coincidence stage (not shown), which requires

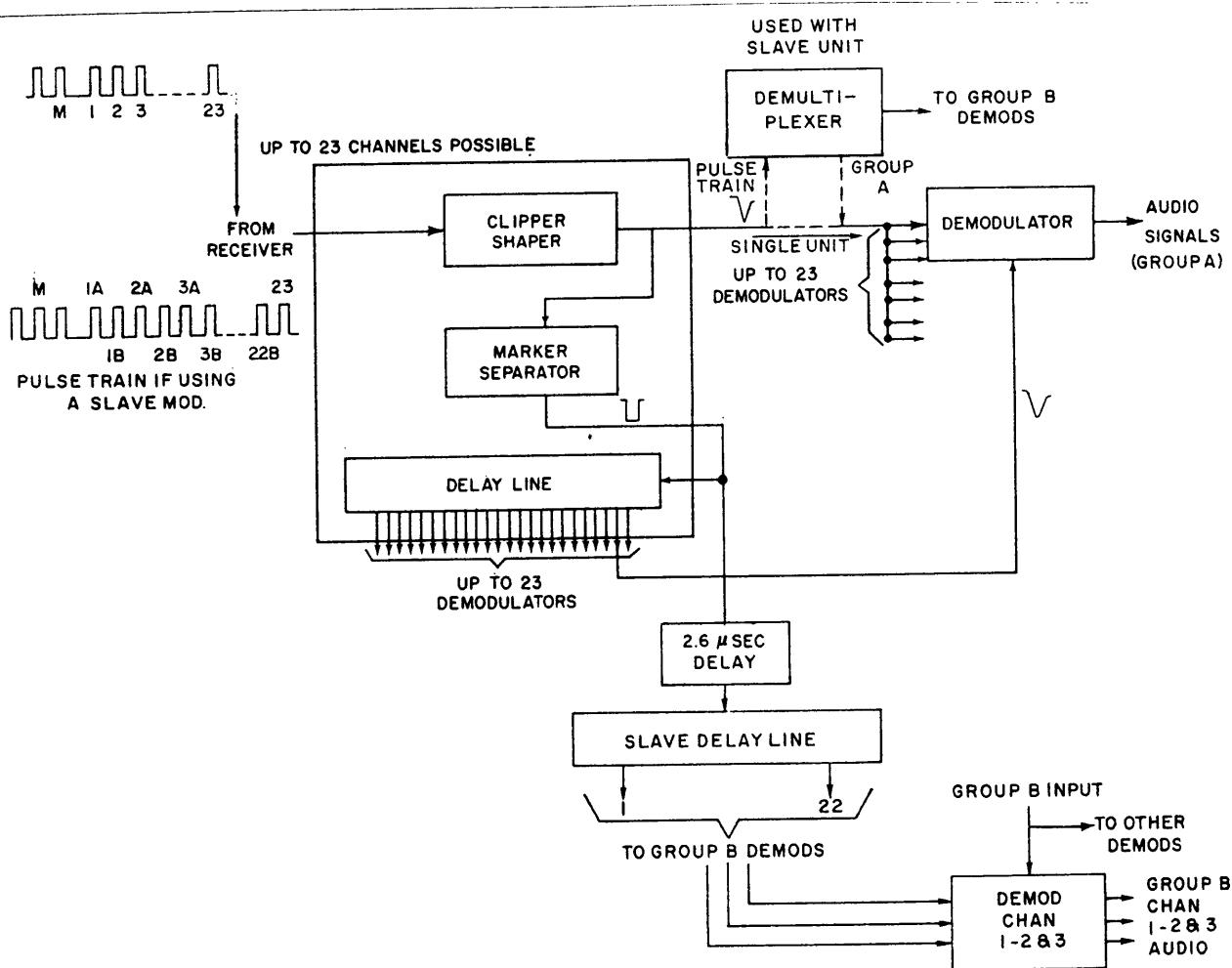


Figure 5-34.—Block Diagram of Multiplex Demodulation Circuits.

the simultaneous application of the channel pulse and the delay line deblocking pulse to cause conduction. The entire video frame is applied to each demodulator. Since the deblocking pulses from the delay line are applied at specific intervals, only one demodulator will be activated for a single interval. The demodulated signals are filtered and amplified and reproduced at the output.

The time division multiplex method just discussed is widely used at Navy communication stations for radio line systems to remotely key transmitters or to modulate transmitters. Each channel could carry a set (3 kHz) of telegraph terminal tones or 1 (3 kHz) voice channel.

If the circuits are needed, another modulator (demodulator) at the receiving end, may be slaved to the first modulator to give a 45 channel output. This may be 45 channels (300-3600 Hz) or 22 channels (300-7200 Hz). Figure 5-32 shows a simplified hookup of the slave unit modulator.

The pulse from the master oscillator (fig. 5-32) is delayed for 2.6  $\mu$ sec and applied to the slave delay line. This gives a combined pulse train spaced 2.6  $\mu$ sec apart (fig. 5-33, B). The marker channel and channel 23 are not used so the output train contains 3 markers and 45 information pulses.

Figure 5-34 shows the demodulator system which requires a demultiplexer unit to separate the master and slave pulses and 2.6 delay line to synchronize the slave delay line gates.

### FREQUENCY-DIVISION MULTIPLEXING

Frequency-division multiplexing (fig. 5-35) is the older of the two methods of multiplexing. In this system, different subcarrier frequencies are modulated by the signals of different channels and then transmitted simultaneously over the same cable or on the same radio-frequency carrier. On the receiving end the channels are separated by filters and are demodulated individually. The total bandwidth required for a frequency-division multiplexing system is the sum of the bandwidths of the

individual channels, plus the sum of the necessary guard-band frequencies between channels.

The resultant signal in each channel will be approximately the same as that which would be produced by the use of a single independent channel, except that nonlinear elements in the system may cause mixing of the various carrier frequencies and crosstalk between channels. Frequency-division multiplexing is a satisfactory multiplexing method for transmission by cable (land line) because equipment is available which gives good fidelity, good signal-to-noise ratio, nearly constant gain, and very low nonlinear distortion.

A greatly simplified block diagram of a frequency-division multiplexing system is illustrated in figure 5-35. For simplicity it may be assumed that the signals are transmitted over a cable; nevertheless a radio carrier could be used.

Channels 2 through 6 each employ an oscillator whose frequency is heterodyned with the audio input to the respective channels in a balance modulator. The frequency produced in the channel as a result of the heterodyning represents an audio modulated subcarrier. A sharp cutoff filter is used in each channel and allows only the passage of the upper sideband. Channel 1 and the 5 upper sidebands are used to modulate the carrier output (transmitter end). There is no need for channel 1 to employ an oscillator; it feeds its audio input (between 300 and 3,000 Hz) directly to the transmitter, and fills the low end of the modulating spectrum.

The bandwidth and position (with respect to frequency) of each of the six channels are indicated at the bottom of the figure. The total spectrum that may be occupied in this particular example is 19.5 kHz.

Only the upper sideband (sum frequencies generated in the balance modulator) is utilized in each channel. The suppressed carrier frequency is indicated by a dashed line between the various channels. This is the frequency used to generate the sideband indicated to the right-hand side of the line. For example, 3.3 kHz

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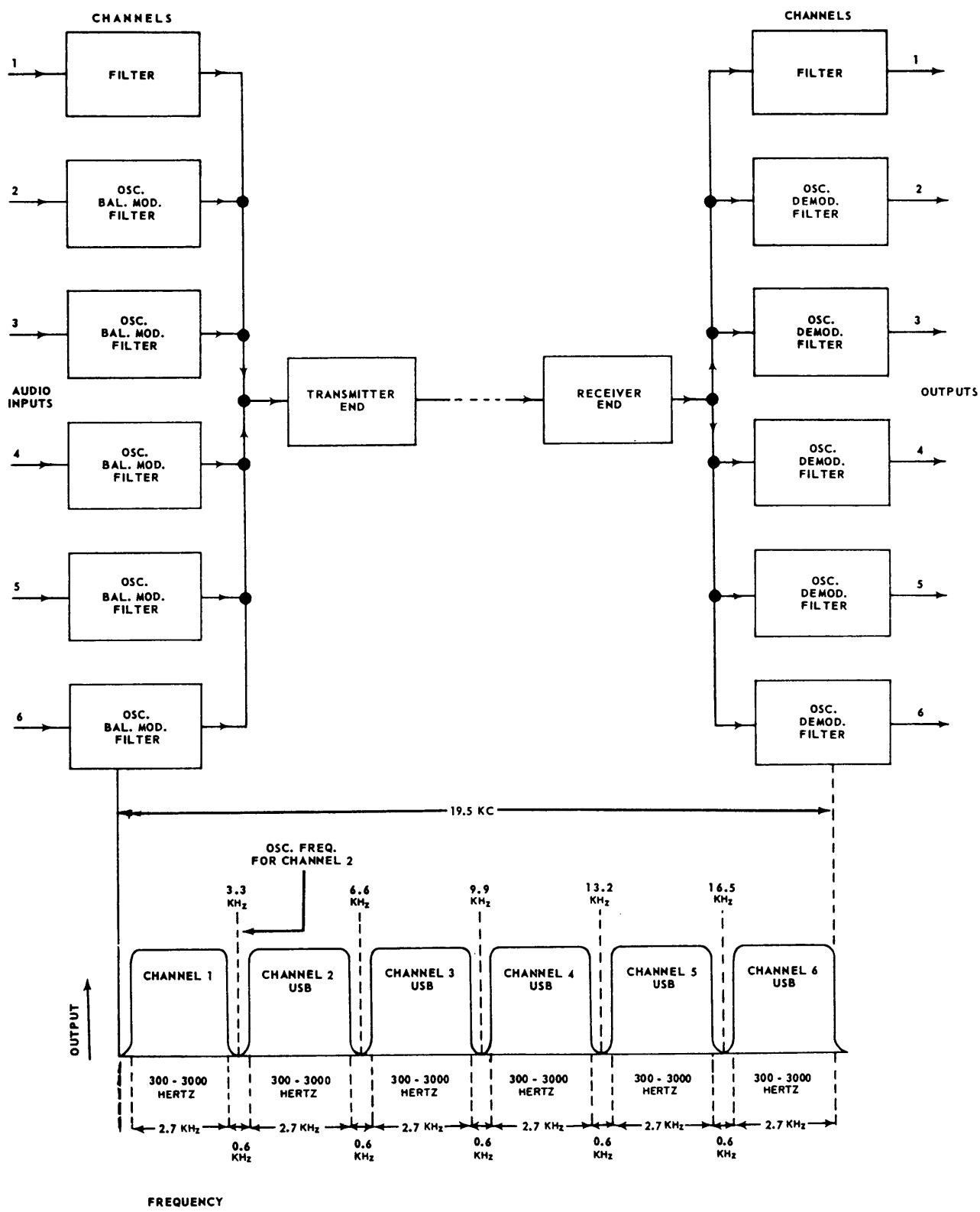


Figure 5-35.—Block Diagram of a Frequency-division Multiplexing System.

is the oscillator frequency for channel 2. Although the upper sidebands are transmitted in this example, the lower sidebands could have been transmitted just as well.

The channel 2 circuits at the transmitter and the receiver are used as examples in the block diagram of figure 5-36. For simplicity, a 1 kHz tone is assumed to be the channel input.

At the transmitter, the 1 kHz signal is fed to the balanced modulator; a 3.3 kHz signal is also fed to the balanced modulator from the channel 2 oscillator. The balanced modulator suppresses the carrier and generates upper (4.3 kHz) and lower (2.3 kHz) sidebands. Only the upper sideband is passed by the channel 2 filter.

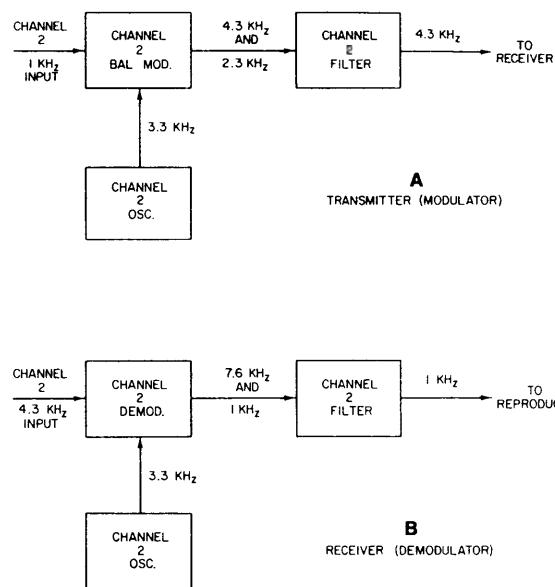
The channel 2 demodulator in the receiver accepts the 4.3 kHz signal and heterodynes this input with the channel 2 oscillator signal (3.3 kHz). The carrier is suppressed, and the two sidebands (7.6 kHz and 1 kHz) are fed to the channel 2 demodulator filter. The filter passes the 1 kHz signal to the reproducer.

### DEMULITPLEXING

As may be expected, the problem of demultiplexing is very similar to that of multiplexing. A simplified block diagram of a demultiplexing system is shown in figure 5-37. This system shows only three channels, although any number may actually be used as was noted earlier.

The output from the receiver terminals (or the signal from the cable if a cable transmission system is used) will have the waveshape of the composite video frames as they were formed by the multiplexing unit. These signals will usually be amplified to a power level capable of operating the associated demultiplexing equipment.

To reconstruct the intelligence from each channel, it is necessary to have a time base that is exactly the same as that of the timing circuit in the multiplexing system. This is accomplished, in the system shown, by using an integrating circuit, labeled "sync separator" in

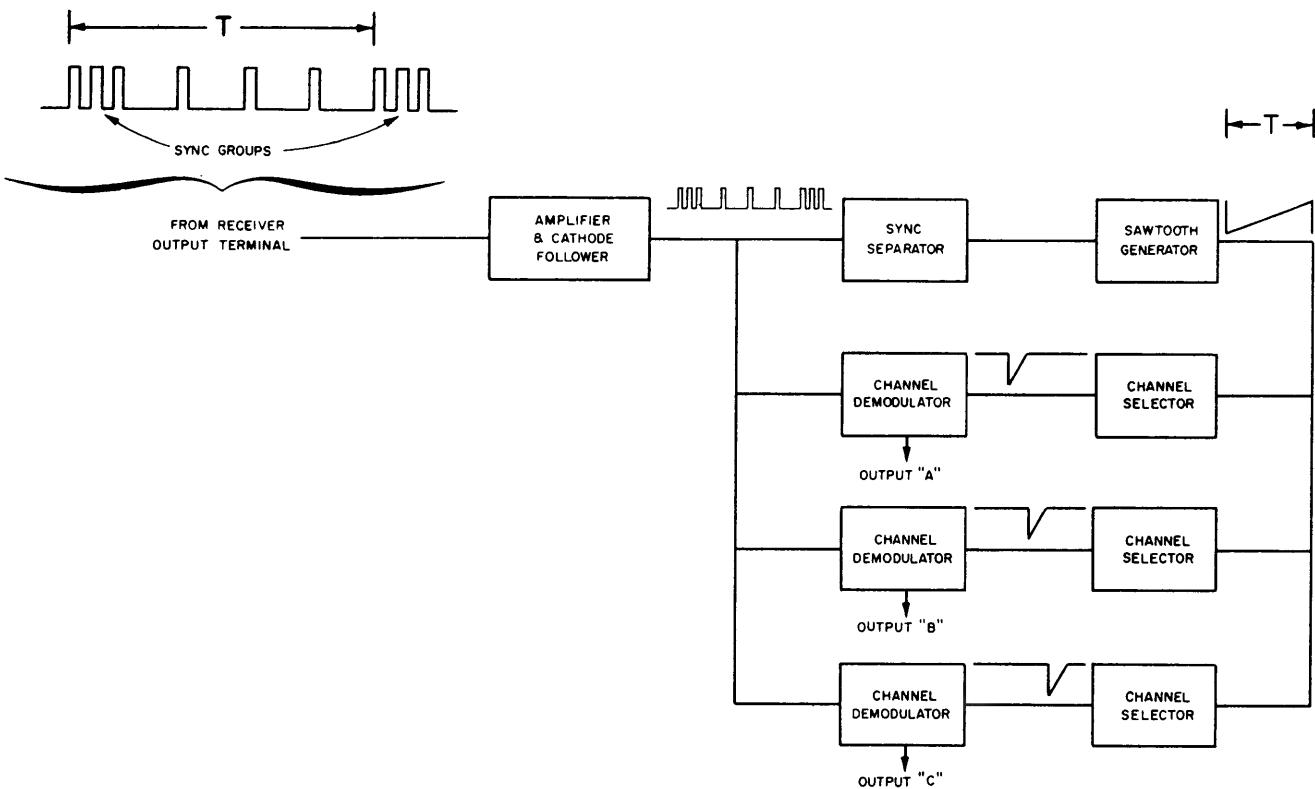


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Figure 5-36.—Block Diagram of a Modulator and Demodulator Units.

the block diagram. This sync separator is designed to detect the "sync group" of the composite wave-form, providing a pulse output that triggers a sawtooth generator. The oscillation frequency of the sawtooth generator is then exactly the same as that used in the timing circuit of the multiplexer.

The output of the sawtooth generator is then coupled to each of the channel selectors. These blocks represent a circuit that can be adjusted to "fire" (i.e., generate a signal) when the sawtooth wave is at the desired amplitude. Since the sawtooth wave is linear with respect to time, the channel selectors then "fire" at the desired instant of time, which is adjusted to correspond to the beginning of the sampling period in the multiplexing channel.

The output of each channel selector is sent to one input of a channel demodulator. Another input of the channel demodulator receives the composite waveform. Each block labeled channel demodulator then represents the circuitry necessary to sample the composite



1.195

Figure 5-37.—Block Diagram of Demultiplexing.

waveform for a specified period determined by the channel selector, thus converting the signal seen during that sampling period back into intelligence information.

### FACSIMILE SYSTEMS

Facsimile (FAX) is a method for transmitting still images over an electrical communication system. The images, called pictures or copy in facsimile terminology, may be weather maps, photographs, sketches, typewritten or printed text, or handwriting. The still image serving as the facsimile copy or picture cannot be transmitted instantly in its entirety. Three distinct operations are performed. These are (1) scanning, (2) transmitting, and (3) recording or receiving.

The scanning operation consists of subdividing the picture in an orderly manner

into a large number of elemental segments. This process is accomplished in the facsimile transmitter by a scanning drum and phototube arrangement.

The picture to be transmitted is mounted on a cylindrical scanning drum, which rotates at a constant speed and at the same time moves longitudinally along a shaft. Light from an exciter lamp illuminates a small segment of the moving picture and is reflected by the picture through an aperture to a phototube. During the transmission of a complete picture, the light traverses every segment of the picture as the drum slowly spirals past the fixed lighted area.

At any instant, the amount of light reflected back to the phototube is a measure of the lightness or darkness of the tiny segment of the picture that is being scanned. The phototube transforms the varying amounts of light into varying electrical signals, which, in turn, are used

to amplitude modulate the constant frequency output of a local oscillator. Then, the modulated signal is amplified and sent to the radio circuits.

Electrical signals received by the facsimile receiver are amplified and serve to actuate a recording mechanism that makes a permanent recording (segment by segment) on recording paper. The paper is attached to a receiver drum similar to the one in the facsimile transmitter. The receiver drum rotates synchronously with the transmitter drum. This action continues until the original picture is reproduced in its entirety. The recording mechanism may reproduce photographically with a modulated light source shining on photographic paper or film, or it may reproduce directly by burning a white protective coating from specially prepared black recording paper.

Synchronization is obtained by driving both receiving and transmitting drums with synchronous motors operating at exactly the same speed.

Framing (orienting) the receiver drum with respect to the transmitter drum is accomplished by transmitting a series of phasing pulses just before a picture transmission is to begin. The

pulses operate a clutch mechanism that starts the scanning drum in the receiver so that it is phased properly with respect to the transmitter.

The equipment necessary for radio facsimile operation and its relationship to other units in the various receiving and transmitting systems are illustrated by the block diagram in figure 5-38. As shown in part A of the figure, the receiving system consists of a standard radio receiver, a frequency shift converter, and a facsimile recorder. Part B shows two systems for transmitting facsimile signals. One, the upper row of blocks, is for long-range, carrier frequency shift transmission and consists of a facsimile transceiver, a keyer adapter, a frequency shift keyer, and a CW transmitter. The other, the lower row of blocks, is for short-range, audiofrequency shift transmission and employs a facsimile transceiver, a radio modulator, and an AM transmitter.

### PROJECT STREAMLINER

The overall objective of Project STREAMLINER is the development of an

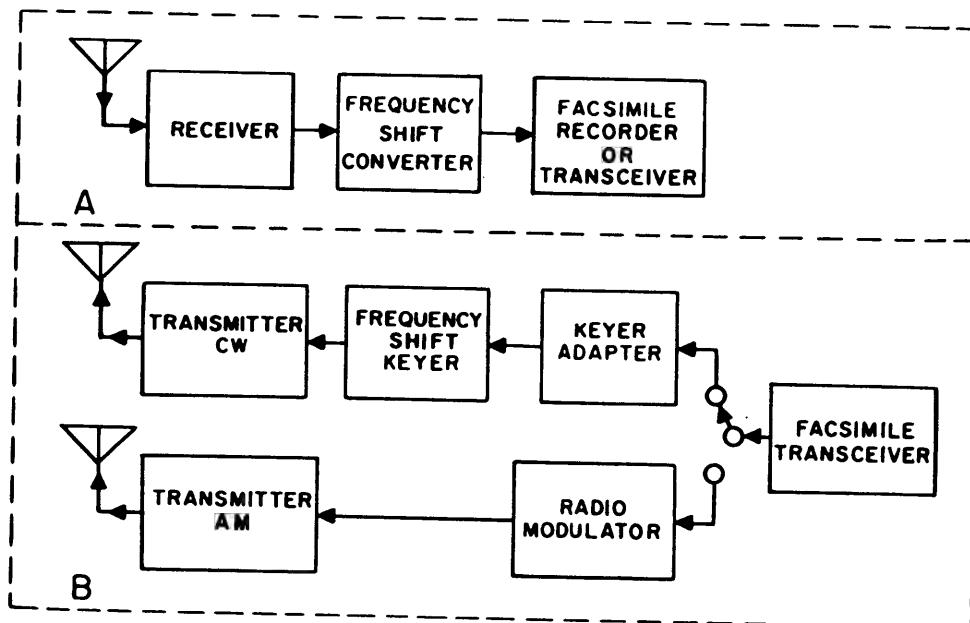


Figure 5-38.—Facsimile System Simplified Block Diagram.

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automated communications system to meet present and future communication needs worldwide.

Project STREAMLINER has improved communications functions related to the initial processing of messages by reducing writer-to-reader time. Model 40 teletype equipments with CRT (Cathode Ray Tube) display as well as OCRs (Optical Character Readers) are installed to speed up message processing. The initial systems are capable of accepting inputs from terminals external to the communications facility. They provide a capability to type, edit, automatically format, release and transmit message data to an outgoing line. At the larger terminal stations, the system is capable of electrical internal distribution. The STREAMLINER ACT (Automated Communication Terminal) is capable of providing varying levels of automation,

depending on the configuration of each system. The STREAMLINER system consists of three different equipment terminals: SACT (Small Automated Communications Terminal) (Figure 5-39) MACT (Medium Automated Communications Terminal) (Figure 5-40), and LACT (Large Automated Communications Terminal) (Figure 5-41).

The following explanatory notes 1-7 and the abbreviations list which follows Note 7 should be used with Figures 5-39, 5-40, and 5-41 to fully understand the capability of each system.

NOTE 1: The standard LACT communications line input/output (I/O) capability is 32. This can be expanded to 48. The standard for a MACT or SACT is 16. A MACT's I/O capability can be expanded to 32 but a SACT's I/O capability is limited to 16.

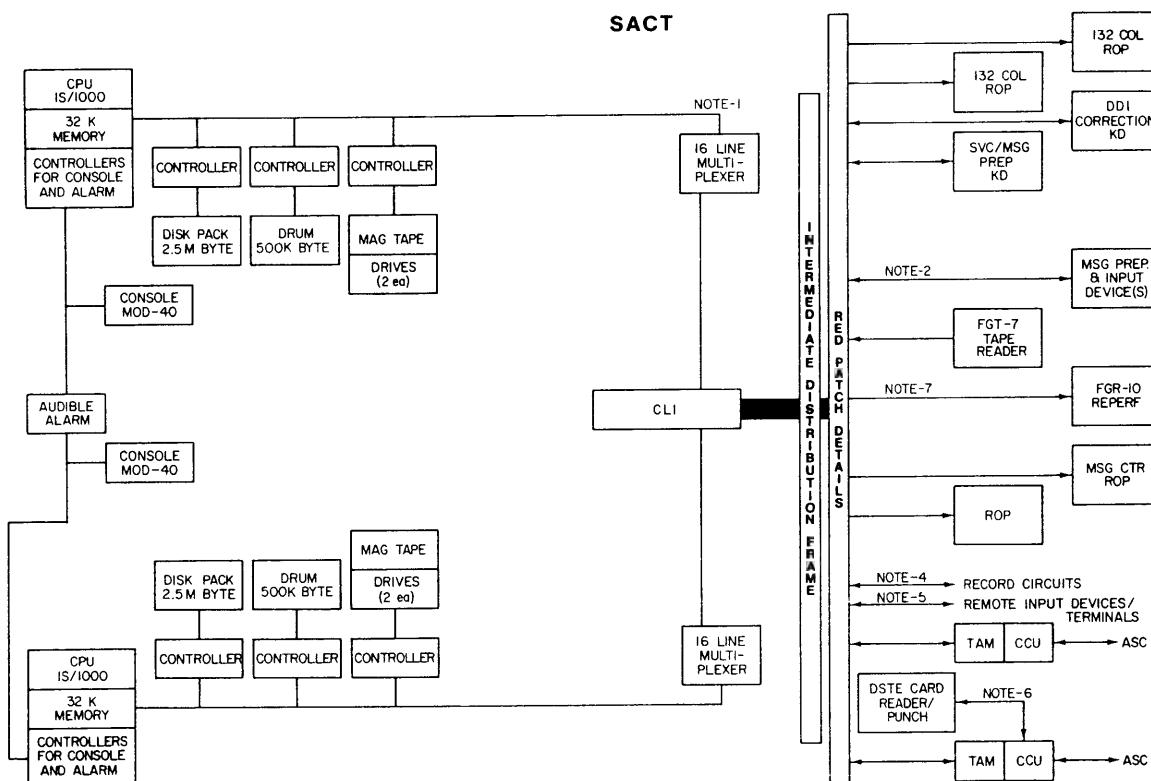


Figure 5-39.—Small Automated Communication Terminal (SACT).

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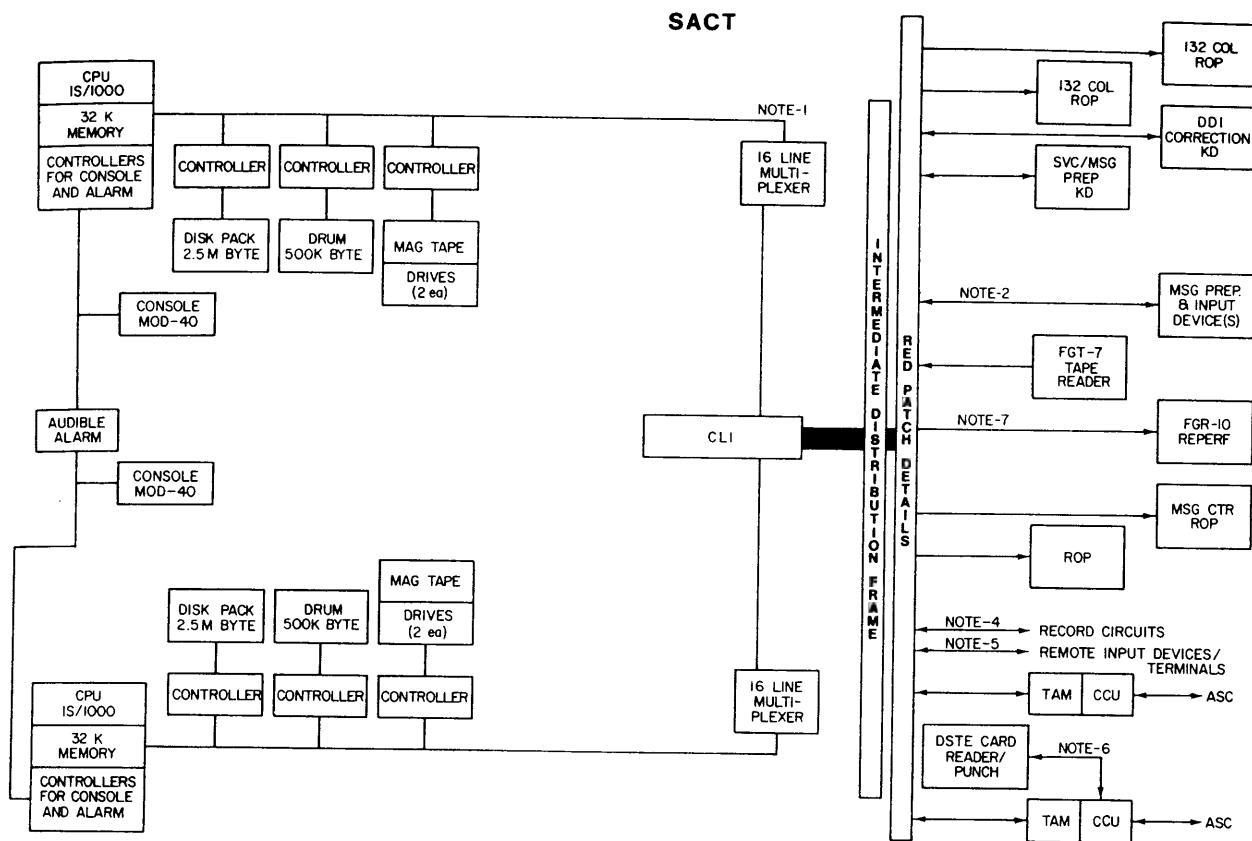


Figure 5-40.—Medium Automated Communication Terminal (MACT).

NOTE 2: Message preparation and/or input devices may consist of one or more OCT's, CRT's, ASR's or combination thereof. The type and number of these devices will be dependent upon the specific requirements of the site concerned.

NOTE 3: DDP's can be either remote or local, consist of ROP's which operate at speeds of up to 2400 bauds and can be connected to the system via a PWDS or secure cryptographic circuitry.

NOTE 4: A record circuit can be any circuit employing DOI-103 or JANAP 128 formats and procedures and using CDSN's for ensuring circuit/traffic continuity. The circuit may operate at speeds of 75-9600 bauds and be connected to the system via a PWDS or secure cryptographic circuitry.

NOTE 5: Remote input devices or terminals can consist of an OCR, CRT, ASR, computer system or a combination thereof. Present requirements limit each I/O line to one type of equipment per line. Connecting circuitry may be a PWDS or secure cryptographic.

NOTE 6: STREAMLINER systems will interface with AUTODIN using the existing DSSCS/DIN Mode I configuration. Stations requiring a card processing capability will use DSTE equipment. The services/SCAs will be responsible for providing the necessary DSTE equipment.

NOTE 7: The recommended paper tape processing configuration is an FGT-7/FGR-10/high speed ROP, or equivalent, to take advantage of the higher operating speeds of the system; however, a low speed Model 28

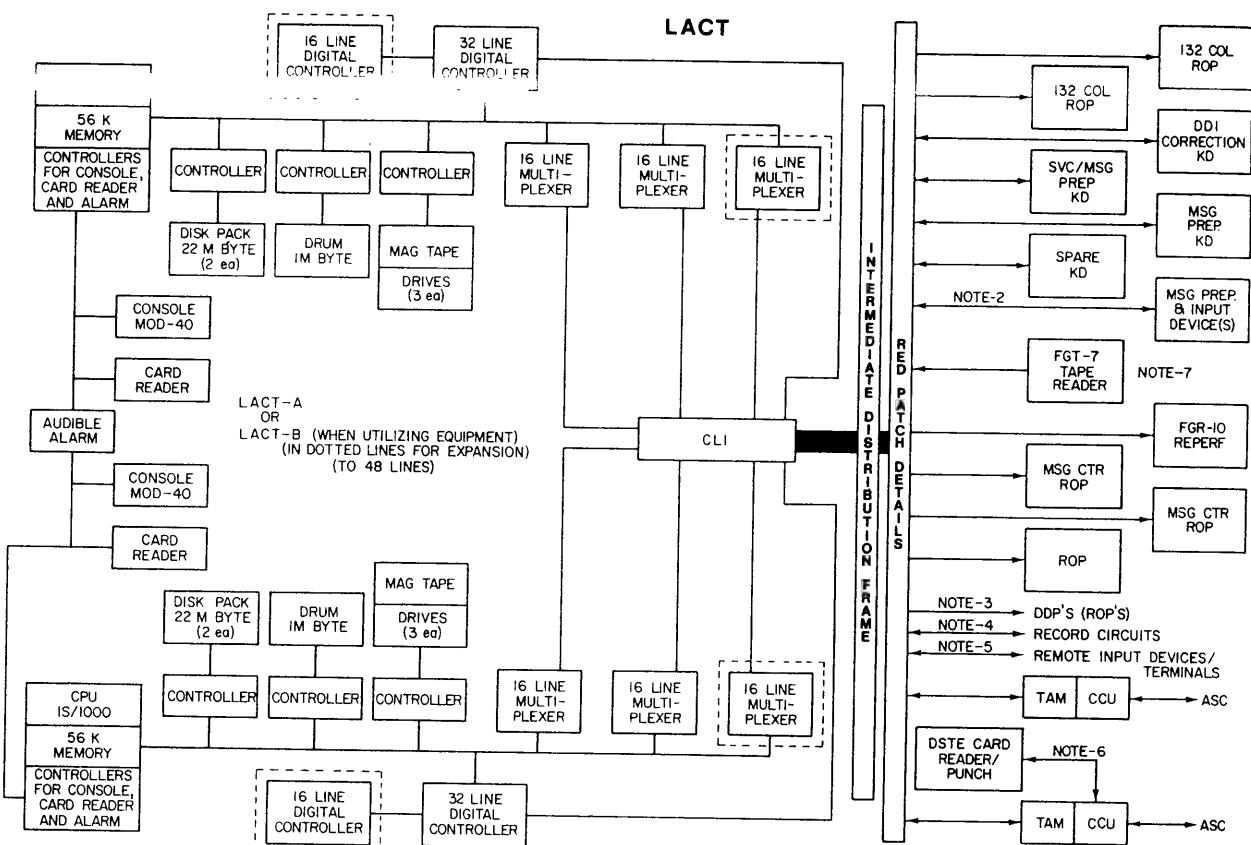


Figure 5-41.—Large Automated Communication Terminal (LACT).

ASR will suffice if the higher speed equipment is not available. Simultaneous operation of the FGR-10 and ROP will be at the option of the operator and will be controlled by an on/off switch.

#### ABBREVIATIONS

ABKS - Alternate Broadcast Keying Station  
 ASC - AUTODIN Switching Center  
 ASCII - American Standard Code for Information Interchange  
 ASR - Automatic Send-Receive Teletypewriter Set  
 BKS - Broadcast Keying Station

CCU - Common Control Unit  
 CD - Channel Designator  
 CDSN - Channel Designator Sequence Number  
 CLI - Common Line Interface  
 COL - Column  
 CPU - Central Processor Unit  
 CRT - Cathode Ray Tube  
 DAG - DSSCS Address Group  
 DDI - Delivery Distribution Indicator  
 DDP - Delivery Distribution Point

DSTE	- Digital Equipment	Subscriber Terminal
FDX	- Full Duplex	
HDX	- Half Duplex	
I/O	- Input/Output	
ICDSN	- Incoming CDSN	
KD	- Keyboard Display (CRT)	
MP	- Message Processor	
MPWG	- Message Procedure Wire Generator	
NARC	- Non-Automatic Relay Center	
OCDSN	- Outgoing CDSN	
OCR	- Optical Character Reader	
PLA	- Plain Language Address	
PWDS	- Protected Wireline Distribution System	
RI	- Routing Indicator	
ROK	- Receive Only Printer with Keyboard	
ROP	- Receive Only Printer	
SN	- Sequence Number	
SSN	- Station Serial Number	
SVC	- Service Message	
TCC	- Transmission Control Code	
TAM	- Teletype Adapter Module	
<b>AUTOMATED COMMUNICATION TERMINAL (ACT) OPERATION</b>		

In network operation, each ACT operates with MIL-STD-188C digital bit rates and interface standards. Access to the worldwide Autodin/DSSCS is provided at each site. All

message traffic is automatically formatted. Automatic PLA(Plain Language Address) lookup and assignment of routing indicators for AUTODIN/DSSCS are performed by the system. Because of limited storage capability, routing indicator tables are structured to permit each site to tailor its table to local requirements.

STREAMLINER has eliminated the majority of tape poke positions, torn tape operations and QC (Quality Control) monitor printers. The reduction in TTY maintenance due to the elimination of the above mentioned functions and the introduction of the new Mod 40 TTY equipment has reduced maintenance manhours in both preventive and corrective maintenance.

STREAMLINER has, in effect, taken the Communications Center from the middle ages into the ADP age in one giant step with mini-computer, disc and tape drive, OCR readers, etc. There has been a vast improvement in message processing capability, system reliability, and most important to maintenance personnel, system maintainability.

#### Streamliner Systems Equipment

STREAMLINER systems are installed in the continental U.S. and overseas locations to provide data and/or narrative digital communications service for the military departments. These systems incorporate various equipments which provide each user the capability to automate the processing of data and/or message traffic. General Telephone Electronics/Information Systems (GTE-IS) has provided the majority of the equipment needed to satisfy STREAMLINER requirements. The vast majority is off-the-shelf equipment of GTE/IS manufacture or selected for use in their product line from other commercial manufacturers. The smaller amount of equipment comprising the communications front end, such as the 16 Line Multiplexing Controller and Common Line Interface (CLI), has been commercially modified or specially designed to meet the purchase description requirements.

GTE/IS utilized a common central processing unit (CPU), IS/1000, for all systems.

Other equipments were selected to meet military requirements, while providing optimum modularity, compatibility and reliability. There is full interchangeability of all IS/1000 components among the SACT, MACT and LACT systems. All system components are easily maintained, being comprised of field proven components and assemblies which has resulted in a high level of system maintainability.

#### CENTRAL PROCESSING UNIT

(CPU).—The IS/1000 is a 16 bit, general purpose mini-computer with high speed (760 nanosecond) memory. The memory is expandable to 512K bytes (byte: a group of adjacent binary digits often shorter than a word that a computer processes as a unit.) with the memory management option. The same basic unit can have other options and modules added to make it serve equally well as a complete multiprogram, multiprocessor, time-sharing computer system.

The IS/1000 can be installed in a 19 inch cabinet using 14 inches of front panel and is only 22 inches deep. The IS/1000 boards utilize integrated circuitry and are field interchangeable. These boards are interconnected by ribbon cables which eliminate the commonly used "mother board" and provide a method in which the maintenance person can easily gain access to the connectors.

Functionally, the CPU has been designed to operate with 94 basic instructions which include load and store, arithmetic, logical, register to register, shift, branch, control and Input/Output (I/O). It features a 256 word read only memory (ROM) for automatic program loading, built-in power failure detections, and other internal interrupts. Its 16 general purpose registers provide programming flexibility.

The 16 bit word transfer rate, by use of I/O instructions (programmed I/O) can be utilized at speeds up to 60K words per second. A faster Direct Memory Access (DMA) with a capability of 1.1M words per second transfer rate is used for all data transfers between the Drum, Mag-Tape, Disc and Communications line Multiplexing Equipment. Up to 64 device

addresses may be used. The capability also features eight asynchronous external priority interrupts with enable/disable masks.

The CPU selected for STREAMLINER has memory modules which are random access, asynchronous ferrite-core stacks with independent current regulation. The maximum memory capacity is 64K words directly addressable in groups of 8K words per memoryboard, or 256K words with the memory management feature added.

The IS/1000 control panel has a full complement of indicators and switches with which system status can be determined. The power requirements for this CPU are 115 volts AC  $\pm 10\%$ , 50/60 Hz, at 8 amps maximum.

**TD-1119/UYQ COMMUNICATIONS MULTIPLEXER.**—The TD-1119/UYQ Communications Multiplexer has 32 simplex communications lines (16 input and 16 output) connected to the I/O Bus of the IS/1000 processor. Each simplex line functions independently from other lines and transfer data at program controlled speeds of 50 bauds to 9600 bauds. The TD-1119/UYQ operates as an intelligent controller providing buffered I/O transfer using DMA. The TD-1119/UYQ accepts queued work requests and is capable of requeueing completed work requests without assistance from the CPU. Various completion notification methods are provided to allow flexibility of application software design. From one to three TS-1119/UYQ multiplexers are utilized depending upon the size of the system employed.

#### Peripheral Equipment

The peripheral equipment selected for use in the various STREAMLINER systems are described below.

**DRUM MEMORY AND CONTROLLER GROUP.**—Drum Memory Model 5320-02 and Drum Controller Group Model 5310-01 is a program-controlled bulk storage, permanent memory device used as an adjunct to the core memory of the IS/1000 computer. The drum

has the capacity to store 256,000 16 bit words on a single drive, with an average access time of 8.7 milliseconds. On the larger systems, (MACT, LACT) the Model 5320-04 Drum with a capacity of 500,000 words is used. Both drums utilize the common controller group Model 5310-01. All data transfer is by direct memory access (DMA).

**DISK STORAGE.**—Model 5062-01 (CAELUS 303/1) Disk provides the IS/1000 computer with up to 2.5 million bytes of on-line storage. The subsystem consists of a controller and disk drive. The disc operates with a single removable disk cartridge having an effective data capacity of 2.5 million eight-bit bytes.

**INTERPRETER TRANSLATER CONTROLLER.**—The controller Model 5061-01 receives instructions from the IS/1000 processor, interprets them, checks their validity, and translates them into signals and sequences compatible with the CAELUS Disc to execute the command functions. Data is transferred between the IS/1000 and the disc using the Direct Memory Access (DMA) channel. The controller provides the IS/1000 processor with the status of the controller and attached CAELUS disk drive.

**DISK MEMORY SYSTEM.**—Disk Memory System, Model 5083-01 consists of a disk controller with one International Business Machine (IBM) 2312 compatible disk drive (MU-637/UYQ) and is directly expandable to two drives. The system is program controlled through use of the High-Rate Input/Output (I/O) operations. The controller provides data buffering to relieve the computer of stringent timing requirements. The MU-637/UYQ provides data checking and cyclic redundancy checking. The data format is IBM-compatible, 346-byte, fixed-length records. This format results in a useable capacity, of 22.35 million bytes per disk pack.

**MAGNETIC TAPE DRIVE.**—Model 5180-06 (Cipher 100X) nine-track, industry-compatible magnetic tape drive capable of reading, writing and storing large volumes of data. It is a program controlled input and output device for the

IS/1000. The Cipher 100X is connected to the processor through the Model 5171-01 Magnetic Tape Controller group, which can accommodate up to four Cipher 100X drives. The Model 5171-01 Controller provides the capability to mix seven and nine track drives, providing they are all the same speed (ips). The Model 5171-01 Controller Generates Parity for each data byte, and a Longitudinal Redundancy Character (LCR) and Cyclic Redundancy Character (CRC) for each record written. During a "read after write" operation, the controller logic checks for character parity, CRC and LRC characters on read data. If an error is detected, the logic sets a bit in the primary device status word to inform the CPU. In addition, file protection is provided by a write lock-out ring on the tape reel.

**CARD READER.**—Model 5140-02 (RP-233/UYQ) Card Reader is a program-controlled input device used to enter programs and data into the IS/1000 computer. The RP-233/UYQ is an end-card reader which reads eighty-column punched cards. An internal timing disk assures accurate column registration, and the metering capstans assure that the card deck can be used many times over.

**OPTICAL CHARACTER READER.**—The Optical Character Reading system (RP-238/GYX) is a flexible, operator oriented, accurate optical character recognition system (page reader) which converts type-written pages into machine language. The scanned text (80 characters per second) is outputted in program controlled data codes normally required by data processing, and telecommunications. The RP-238/GYX reads separate sheets up to 11 inches wide and 24 inches in length. It reads a wide variety of fonts, including Perry, Courier-12, OCR-A, OCR-B, European accented fonts, etc., however only the OCR-B font option is used in Project STREAMLINER. The minimum error rate is less than one in 25,000 characters, and can be much higher depending upon the character set used and the quality of the input material. The RP-238/GYX major components consist of an integral microprocessor with core memory, a keyboard, scanner, stack feeder, two control panels, and a

signal output unit to drive peripheral equipment. The microprocessor controls the operation and allows the user to quickly and easily set the OCR to any particular set of typing rules (format) and output codes through the use of HEADER SHEETS. Formats and codes can easily be changed as required.

**R E C E I V E O N L Y P R I N T E R T E R M I N A L.**—The Teletype Model 40 Receive Only Printer Terminal (ROP) consists of a tractor feed printer, an operator control strip, printer enclosure and pedestal. The controller can be conditioned to receive asynchronous (free running internal clock) data or isochronous (bit stepped from external clock) data. The data can be either ITA2-AV (Baudot) or ITA5 (ASCII) codes. There is an 800 character input buffer, allowing reception of a series of short lines. The printer is arranged to print 63 graphics in columns 2 through 5 of ASCII codes at a rate of 300 lines per minute. There are two printer versions, the interface assembly and a logic assembly. The logic assembly, containing the terminal controller and power supply, is in the pedestals of all of the above mentioned Model 40 Teletype Terminal Sets. The controller can be conditioned to send and receive asynchronous (free running internal clock) data or isochronous (bit stepped external clock) data. The data can be either ITA2-AV (Baudot) or ITA5 (ASCII) codes.

The operator control strip has keytops to select the four modes of operation of the terminal, mainly Send, Receive, Local and Conversational; along with status indicators showing the active condition of the terminal. Status indicators show whether the terminal is capable of sending or receiving data.

The display unit has the capacity of 72 lines of display with 80 characters per line. There are capabilities for highlight, tab control and protected data by operator control. There is full editing capability of character and line delete and insert keys on the keyboard. Full cursor control consisting of up, down, left, right, return and home keys. The display has its own tilt and brightness controls.

The Teletype Model 40 and other associated terminal equipment is described in greater detail later in this chapter.

## DIRECT CURRENT DISTRIBUTION

Distributing the desired d.c. teletype signals throughout the communications installation requires a reliable method of control, and a variable amount of equipment designed specifically for this purpose. These equipments are of a modular design and allow a variety of equipment configurations to be installed. However, the overall usage is the same at all installations.

## DISTRIBUTION FRAMES

The standard practice at all Naval Communications Stations requires that all communication equipment control wiring, patching, and monitoring facilities be wired through a distribution frame. The purpose of a distribution frame is to eliminate "permanently patched" circuits under normal operating conditions and provide the flexibility of change.

This is accomplished by permanently wiring or "normalling" through the patch panel all circuits which under normal operating conditions would otherwise have to be permanently patched together. The facilities for patching such circuits are not eliminated since they will still be required for temporary circuit monitoring, testing, and maintenance.

Distribution frames are identified by their employment (e.g., Main Distribution Frame and Intermediate Distribution Frame). Overall wiring flexibility is accomplished through patching systems. The patch panels (to be discussed later) are actually wired in parallel with the distribution frame wiring so that under normal circumstances the signal will be normalled through the patch.

### Cross-Connects

Cross-connects are wires that interconnect terminals of the distribution frame terminal blocks. These wires may interconnect terminals on the same block or may run from one block to another. Of the types of termination authorized

for cross-connects, solder type termination is the one most often used.

Cross-connects are made of wire designed especially for distribution frame use. To facilitate wiring this cross-connect wire is color coded and is available in singles, pairs, triplets and quads. Western Electric Company Type V is commonly used as the cross-connect for a distribution frame.

The cross-connect wires should be run in a manner that presents a neat uniform pattern. Each cross-connect should be run loosely to insure adequate length and to facilitate relocation or removal as required. In general, any practice that will cause the cross-connect wire to tangle, or otherwise become caught on lugs or other objects, should be avoided. When twisted pair, triplet or quad cross-connect wire is used, the conductors should be untwisted at each end so that each conductor enters the terminal block fanning strip individually. However, the wire should not be twisted more than one regular twist back of the fanning strip. A color code compatible with Red or Black, high or low level operation has been established for single conductor cross-connect wire as shown below:

DC SEND LINE.....	GREEN
DC SEND LINE RETURN.....	GREEN/WHITE
DC RECEIVE LINE.....	ORANGE
DC RECEIVE LINE RETURN.....	ORANGE/WHITE
VOICE FREQUENCY SEND LINE.....	BLUE
VOICE FREQUENCY SEND LINE RETURN.....	BLUE/WHITE
VOICE FREQUENCY RECEIVE LINE.....	BROWN
VOICE FREQUENCY RECEIVE LINE RETURN.....	BROWN/WHITE
SEND CONTROL.....	GRAY
RECEIVE CONTROL.....	VIOLET
+6V BATTERY .....	RED
-6V BATTERY .....	BLACK
GROUND.....	WHITE
ALARM.....	YELLOW

### Main Distribution Frame (MDF)

The MDF is the division point between facilities control and the transmitter/receiver site. All trunk lines entering and leaving facilities control are terminated at the MDF.

### Intermediate Distribution Frame (IDF)

The IDF is used as an intermediate tie point for unclassified circuits between the MDF and cryptographic equipment via the BLACK patch panel. The IDF provides a point at which to cross-connect the trunk lines/patch panel jacks/cryptographic equipment for normal-through operation. In some installations, the IDF may be incorporated into an MDF.

### Classified Intermediate Distribution Frame (CIDF)

The CIDF is used for termination of circuits which carry classified information between the cryptographic equipment and the teletype terminal equipment via the RED patch panel. The CIDF function is similar to the IDF, however, current security regulations prohibit the termination of circuits carrying classified information to the same distribution frame as those carrying unclassified information. Security regulations also require a separation between distribution frames at which classified information circuits are terminated, and those carrying unclassified information.

## FACILITIES CONTROL OPERATIONS

Facilities control operations, formerly called technical control operations, is an integral section of every communications installation; established to perform the functions of circuit and equipment control. As the technician assigned maintenance tasks involving cryptographic and teletype terminal equipment, you will become very familiar with facilities control operations and will work closely with the facilities control personnel. The facilities controllers are capable of providing a very high degree of assistance involving systems troubleshooting. The facilities controllers perform

the crypto/teletype/line patching as necessary, ensure circuit continuity and provide signal analysis.

## TRUNK LINES

Each trunk line is given a circuit identification code. At the receiver/transmitter site the trunk line is permanently cross-connected to the channel of the multiplex equipment desired. At the facilities control end it is permanently cross-connected in the IDF to the desired cryptographic equipment. The trunk line is also connected to a patch panel at both ends to allow it to be spared off, or other equipment to be patched in, if necessary. These lines are normally polar keyed and operate on a 20 milliamper signalling current.

At the receiver/transmitter site these trunk lines may run to conversion relays. The conversion relays change the keying from neutral to polar or from polar to neutral.

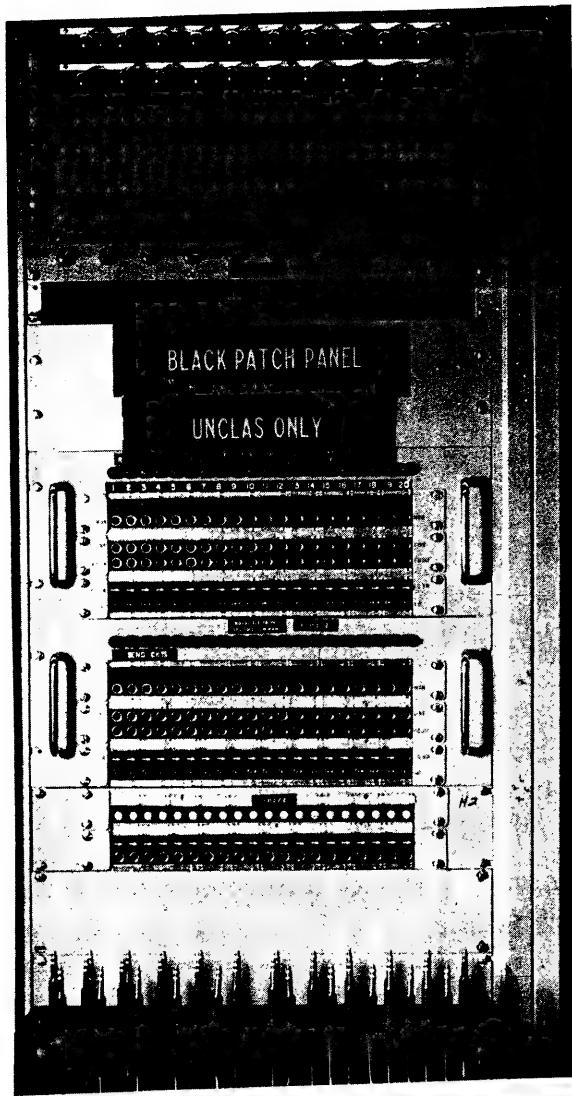
Some installations have located the conversion relays in facilities control. The trunk lines in these cases are neutral keyed and conversion takes place "in-house."

## BLACK Patch Panel

The BLACK patch panel provides patching capability and control for all unclassified d.c. trunk lines and crypto equipments. In addition, the BLACK patch panel, as shown in figure 5-42 has ancillary equipment installed in it for various purposes (e.g. meter, alarms, fuses, line current controls, etc.).

The patch module (fig. 5-43A) used in the BLACK patch panel consists of monitor jacks, line jacks and equipment jacks.

Depending on the patch panel configuration, the jack rows may be set up in pairs (e.g. #1 send- #2 receive- #3 send- #4 receive, etc.), or all send circuits on one panel and all receive circuits on another. A maximum of four modules may be installed in one cabinet, but normally two modules will fill most station requirements.



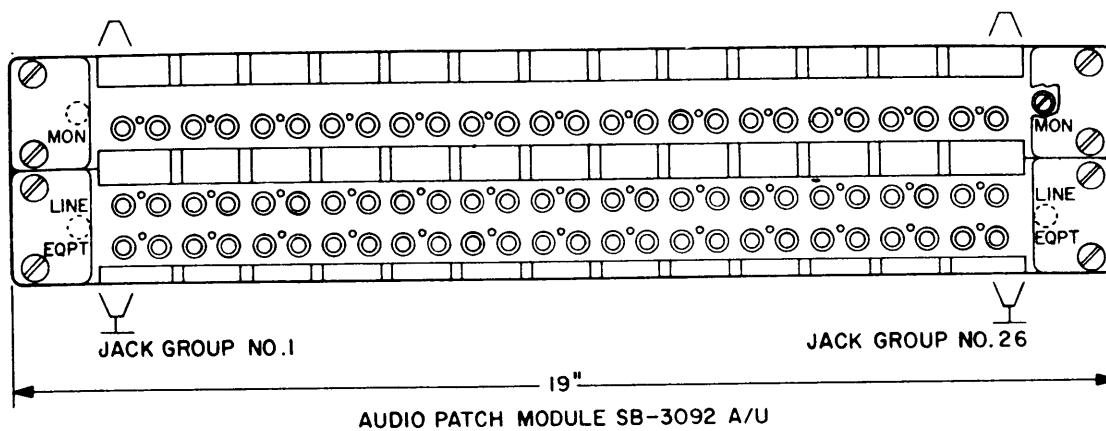
31.66

Figure 5-42.—Unclassified Patch Panel (BLACK).

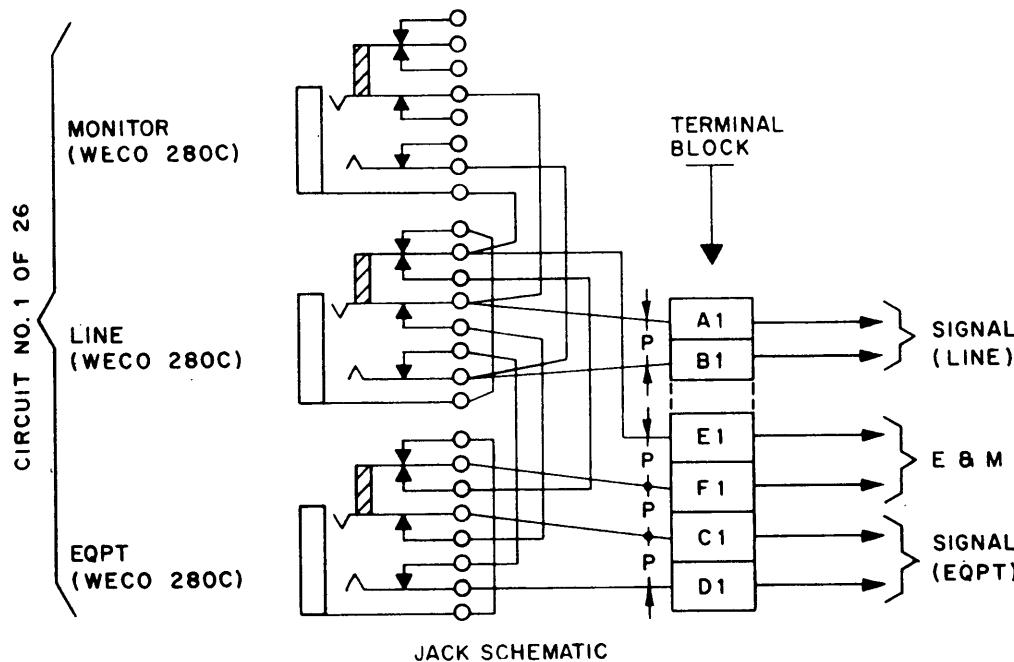
The jacks are wired so that under normal circumstances each circuit and its associated equipment will operate without the use of patch cords (figure 5-43B).

Circuits are assigned to specific details on the patch panel. Each detail consists of five appearances, activity lamp, monitor jacks, line jacks, equipment jack and control switch (see figure 5-44).

Monitor jacks permit lines to be analyzed or monitored without the interruption of traffic flow.



A



B

1.435

Figure 5-43.—Basic Audio Patch Module, SB-3092/AU.

When a patch cord is inserted into a line or equipment jack, that particular jack becomes electrically disconnected and the equipment or line is transferred to the patch cord. Using the other end of the cord, the equipment or line can be electrically connected to any other jack.

The control switch in each jack detail is used to control or to "cut off" the signal flow either

to or from the trunk line. The switch is rotated between vertical and horizontal positions to control the signal flow. The switch is marked with an arrow in order to recognize its position. The circuit activity lamp merely indicates which particular line is in use.

Another smaller separate patch panel may also be installed in the BLACK patch panel. This

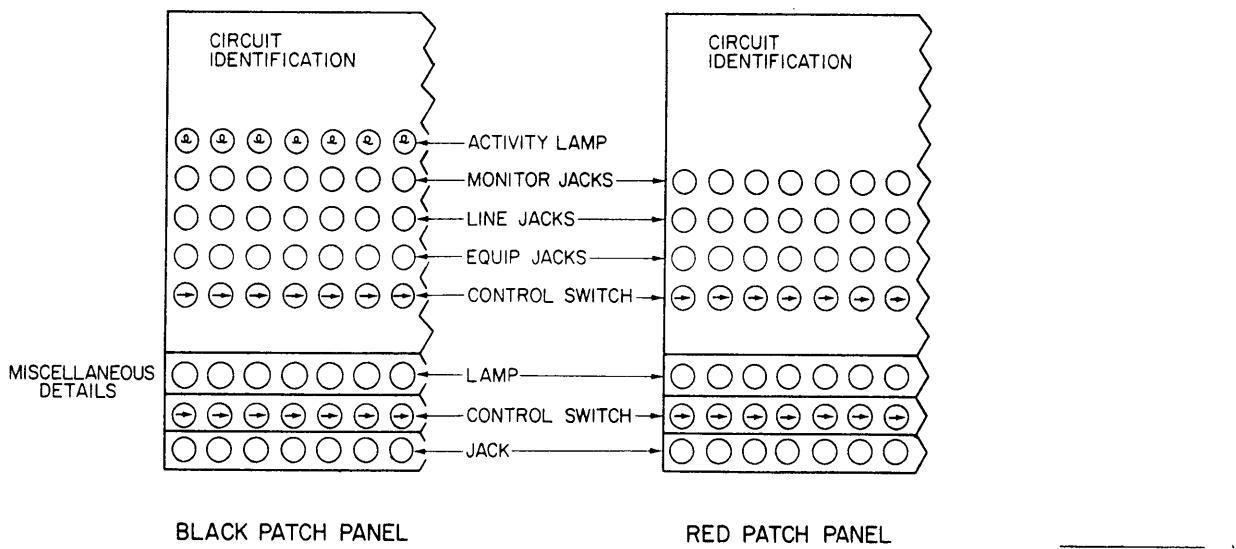


Figure 5-44.—Standard Details on a Black and Red Patch Panel.

31.127

is the "miscellaneous" patch panel, and, as the name implies, is used for miscellaneous equipment or functions.

Each patch panel bay, of the type previously described, has a cord shelf extending out from the panel. The shelf holds the retractable patch cords and also provides a writing space.

The patch cords contain the same three-wire (ring, tip and sleeve circuits) system as the jacks in the patch panel. The three-wire circuits in the cords and jacks are briefly described below:

1. **TIP.** The tip of the patch cord carries the intelligence signal.
2. **RING.** The ring of the patch cord carries the synchronizing or "step" information and/or timing information.
3. **SLEEVE.** The sleeve of the patch cord carries the supervisory or alarm circuits.

Patch cords are usually color coded (white, red, black, and green) and have five different uses:

1. **SEND.** The send cords are white with a single plug; the other end is permanently

(hard-wired) to a keyboard position in the facilities control spaces.

2. **RECEIVE.** The receive cords are red and have a single plug; with the other end hard-wired to a monitor printer in the facilities control spaces.

The number of send and receive cords will vary according to the size of the facility and the number of terminal positions available.

3. **TEST.** The black test cords are designed the same as a SEND cord, with a single plug. The other end is hard-wired to electronic test keyers.

4. **METER AND SCOPE.** The meter and scope cords are also black and designed as receive cords, with a single plug. A push-to-read button is also associated with the meter cord to protect the meter from inadvertent shorts.

5. **PATCHING.** Cords used for patching are green, double-ended and may be patched from either end. Neither end of the cord is hard-wired to a position or facility in the facilities control spaces. Patch cords are wired tip to tip and ring to ring, giving straight through reproduction of any signal on these two circuits.

By manipulating the patch cords, the facilities controller can test out and/or

interchange normal or spare lines and equipment as necessary. In the event of equipment failure, or when changes occur in operational requirements, the controller can virtually patch to or around any position on the jackfield.

### CRYPTOGRAPHIC EQUIPMENT

Though there are several different models of on-line crypto equipment in use throughout the Naval Security Group, they are all designed to perform the same function. This function is to encipher or decipher a teletype, voice, or digital data signal.

Basically, the crypto transmitter accepts a "plain text" signal containing classified intelligence, adds a "key" (randomly chosen marks and spaces) generated from within and transmits the sum as "cipher text", more formally referred to as an enciphered signal. The crypto receiver accepts the enciphered signal and generates a key to match the one generated by the transmitter. The receiver subtracts the key from the cipher text input signal, which restores the plain text signal, and passes it on to the RED patch panel for dissemination to the terminal equipment.

Navy security regulations prohibit unauthorized personnel from making repairs or adjustments to cryptographic equipment. Only those personnel trained by an accredited United States Armed Forces Service School, and having a valid FORM DD 1435 (Cryptographic Maintenance Training and Experience Record) filed in his service record, may be assigned maintenance responsibility of cryptographic equipment. A further requirement, reflected on the FORM DD 1435, is actual maintenance experience within the previous 36 months on the cryptographic equipment to be repaired or adjusted. The crypto maintenance member should ensure that FORM DD 1435 is updated every 12 months or prior to a permanent transfer with the appropriate entries reflecting his qualifications.

#### RED Patch Panel

The RED patch panel provides patching and control facilities for all classified information

originating from teletype and crypto equipment. (See figure 5-45.)

The patch module used with the RED patch panel is, with one exception, electrically and mechanically of the same design as the patch module used with the BLACK patch panel. The absence of circuit activity lamps in the RED patch panel is the exception.

The "LINE" jacks are the termination points for the cryptographic equipment on the RED patch panel and the "EQUIPMENT" jacks are the termination points for the teletype equipment. The jacks all function in the same manner as those on the BLACK patch panel.

As with the BLACK patch panel, the RED patch panel has ancillary devices installed for monitoring, metering, and so forth.

Another function of the RED patch panel not normally found in the BLACK patch panel is the "STEP" signal. This signal is a timed pulse emitted by the crypto transmitter used to synchronize teletype keyboard/transmitter distributor (tape reader) with the crypto equipment.

The step pulse actuates a clutching circuit, causing the keyboard or transmitter-distributor to "lock-up" (stop sending) momentarily. This action slows the teletype output to match the crypto transmitter's circuit timing.

#### BATTERY SOURCES

Patch panel batteries used between crypto equipment and the conversion relays to supply keying current, is normally provided by a  $\pm$  6 v.d.c. power supply located in the patch panel. Most installations maintain a spare  $\pm$  6 v.d.c. power supply that may be switched into use in case of emergency.

At recent installations the patch panel battery is "low-level." Power is  $\mp$  6 v.d.c. obtained from two automobile-type batteries. The batteries are kept at the desired 6 v.d.c. charge by utilizing a trickle charger for each

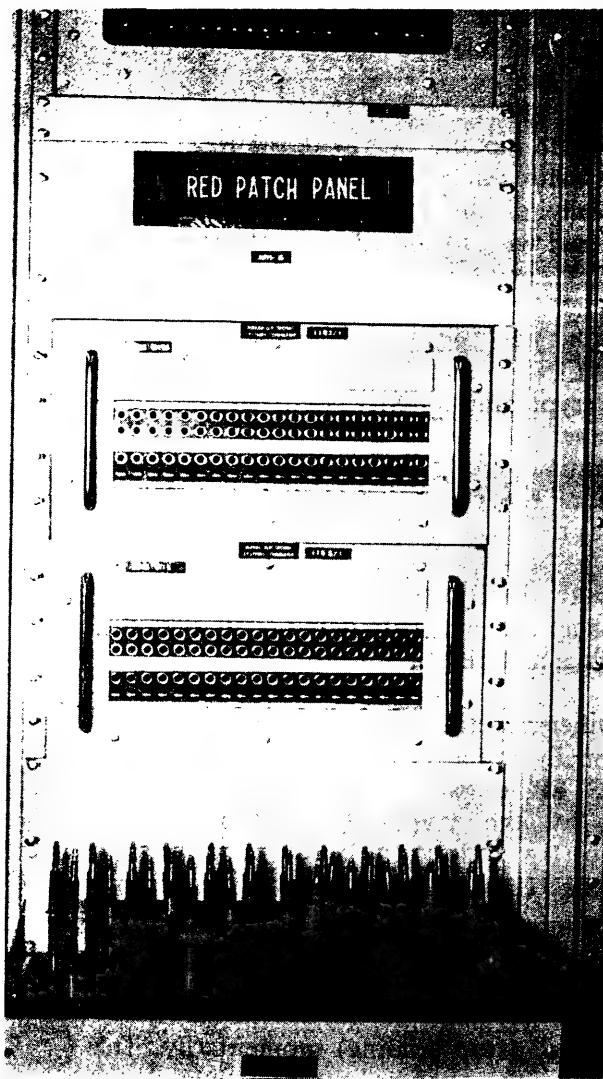


Figure 5-45.—Classified Patch Panel (RED).

battery. A spare charger may be switched to either battery if needed.

#### INSTALLED TEST DEVICES

To provide signal analytical capabilities for the facilities controller/technician, a signal analysis system is incorporated into the BLACK patch panel. The system consists of an oscilloscope for visual signal display, a signal analyzer for signal distortion analysis, and a signal generator for generation and transmission of a "Fox" test or other test signals.

#### Digital Data Distortion Test Set AN/USM-329 (V)

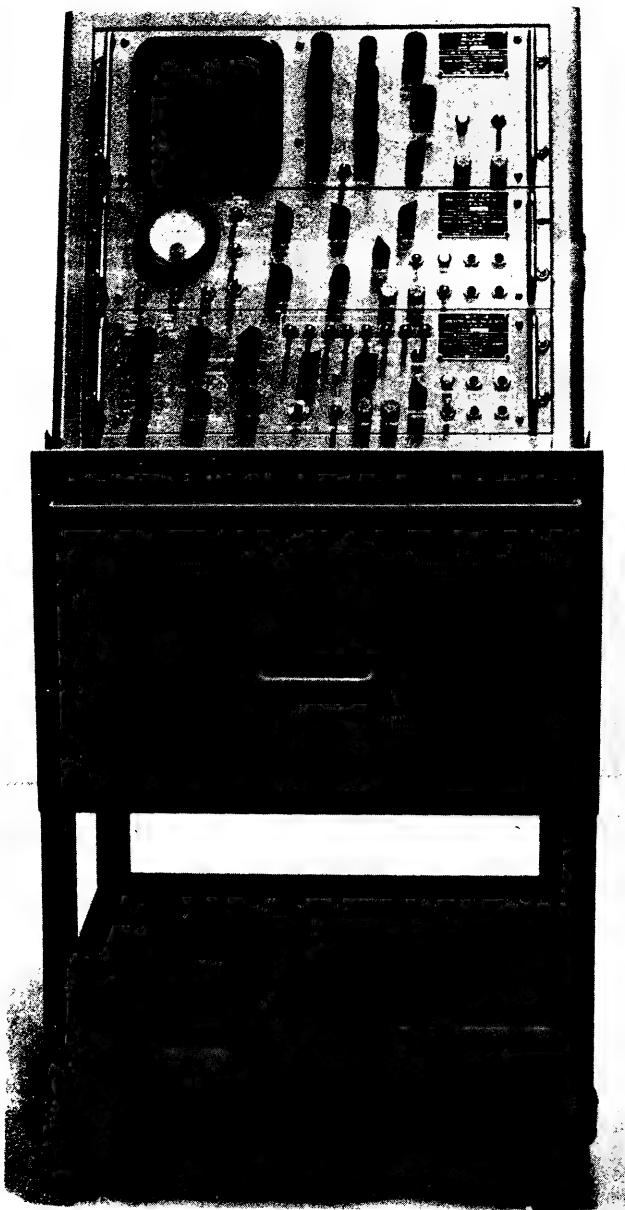
The AN/USM-329 (V) is one example of the type of distortion analysis equipment which the technician may encounter in the field.

The AN/USM-329 (V) (figure 5-46) is designed for installation in a standard 19-inch cabinet. Each of the three component units are self-contained and operable independently, although the analyzer and oscilloscope are normally operated together. This test set provides the analytical functions and range to cover virtually all communication requirements encountered in the field.

**DIGITAL DATA SIGNAL GENERATOR SG-885(P)/USM.**—The digital data signal generator portion of the AN/USM-329 (V) (figure 5-47) generates a wide variety of outputs for test purposes. These outputs are: a standard "FOX" message with 5-letter programmable field for station call letters; steady mark; steady space, reversals 1:1, or selected repetitive characters. The output baud rates cover a wide spectrum and consist of: 37.5, 45.5, 50, 61.12, 74.2, 75, 150, 300, 600, 1200, 2400, and 4800. The signal generator also has the capability of introducing from 0 to 49 percent distortion, in 1% steps, into the test signal. The types of distortion available are: marking bias; spacing bias; switching bias; marking end, and spacing end.

Output line keying may be  $\pm$  6 v.d.c. (low-level) polar, or  $\pm$  60 v.d.c. (high level) polar or neutral.

**DIGITAL DATA SIGNAL ANALYZER TS-2936 (P)/USM.**—The digital data signal analyzer unit of the AN/USM-329(V) (figure 5-48) is used to determine the amount of and types of distortion of digital data and teletype signals. The analyzer provides a meter readout capability to show the percentage of distortion of the received signal. Used in conjunction with the OS-212/USM oscilloscope, which gives a visual display of the signal, a very useful analysis of the waveform is made available to the facilities controller/technician.



31.135  
Figure 5-46.—Digital Data Distortion Test Set AN/USM-329(V).

**OSCILLOSCOPE OS-212/USM.**—The oscilloscope OS-212/USM (figure 5-49) may be used independently or together with the digital data signal analyzer TS-2936 (P)/USM. When utilized with the signal analyzer, the oscilloscope performs the function of displaying the waveform for comparison with the meter readings on the analyzer.

### Teletype Signal Distortion

An ideal teletypewriter circuit reproduces signals at the receiving end exactly as they are impressed at the sending end. Unfortunately, this seldom happens under actual operating conditions. Any deviation of a signal parameter (such as time, amplitude, or waveshape) from that of the ideal signal is called distortion. Distortion in teletype signals is due to various causes and is controlled by design and proper maintenance. The overall or total resultant distortion of signals for a given telegraph circuit is the combined effect of two principal types of distortion. These types are systematic and fortuitous.

Assume that a given character is sent continuously over a telegraph circuit, and that each repetition of the character is considered perfect as sent. Measurements of the distortion of each of the unit marks (elements) in a large number of successive repetitions of the character at the receiving end will generally indicate that the distortion differs from element to element in a given repetition of the character, and from character to character for a particular element in the character. The average of a large number of distortions for a particular element is designated as systematic distortion. The individual departure of the distortion from the average as fortuitous distortion. The total distortion of each signal element is the algebraic sum of the systematic and fortuitous distortions, and is the amount of deviation between the sent and received signals.

Systematic distortion may be subdivided into bias, end, characteristic, cyclic, and peak distortion, as shown in figure 5-50.

**BIAS DISTORTION.**—Bias distortion is the uniform lengthening or shortening of the mark or space elements, one at the expense of the other (fig. 5-51, parts A, B, and C). The lengthening of the marking elements is called marking bias distortion, and the lengthening of the spacing elements is called spacing bias distortion. The degree of bias distortion is expressed as a percentage of the unit interval. In start-stop operation, bias appears as the displacement of the space-to-mark transitions

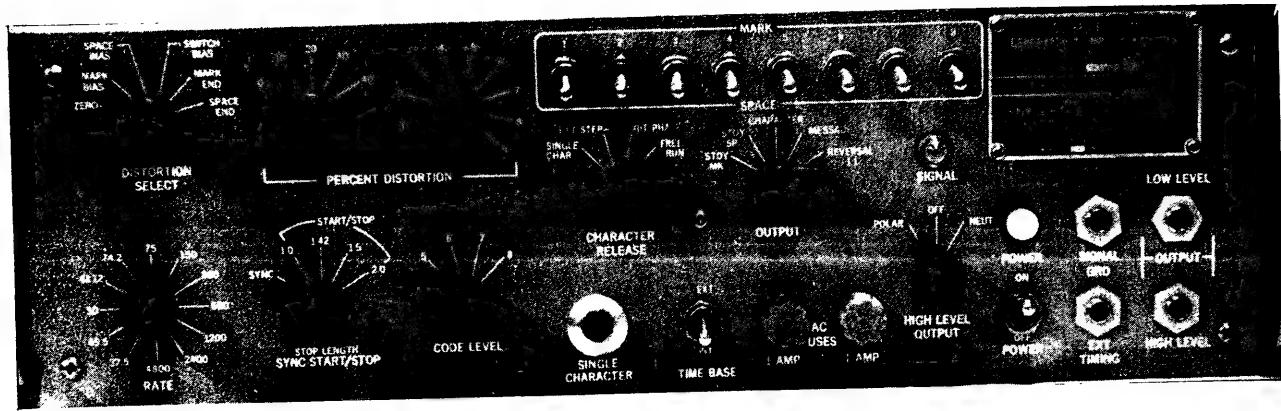


Figure 5-47.—AN/USM-329(V) Signal Generator SG-885(P)/USM.

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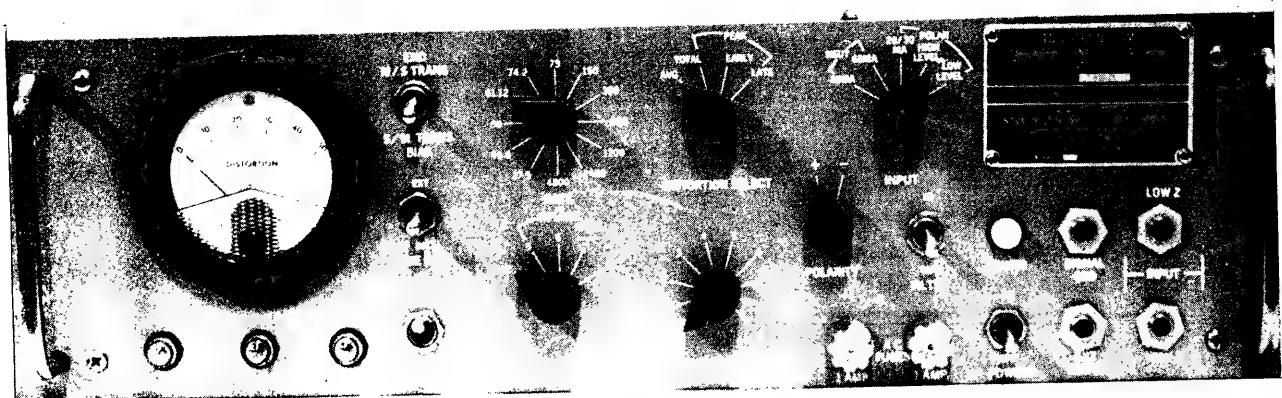


Figure 5-48.—AN/USM-329(V) Z Signal Analyzer TS-2936(P)/USM.

31.137

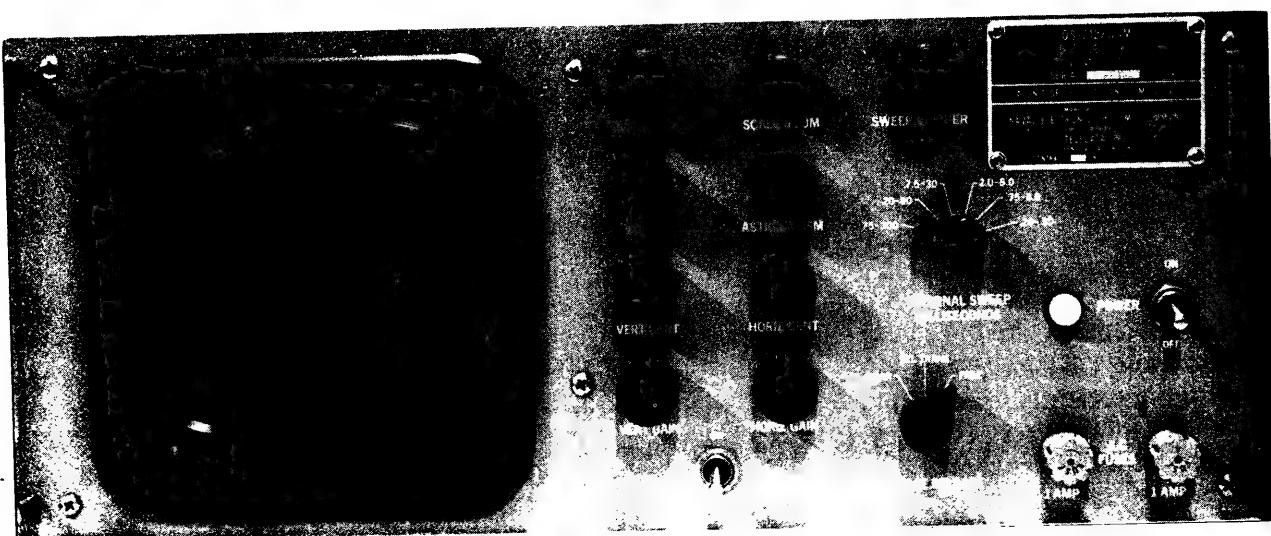
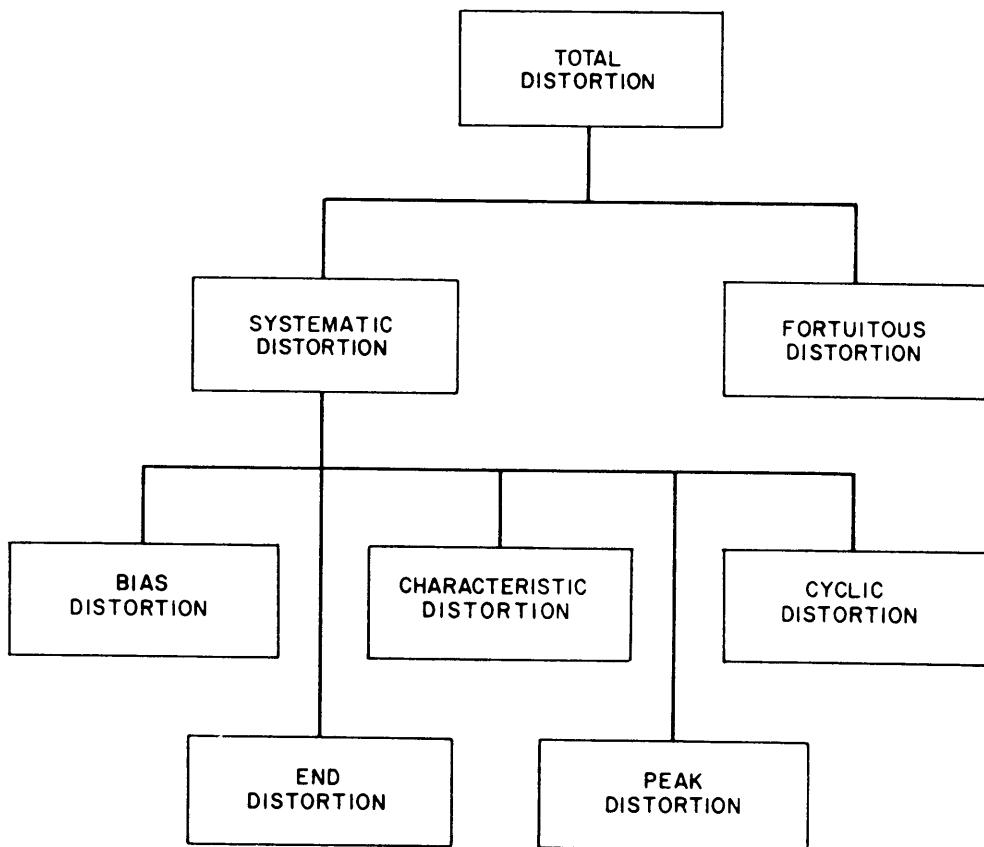


Figure 5-49.—AN/USM-329(V)2 Oscilloscope OS-212/USM.

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Figure 5-50.—Teletype Signal Distortion.

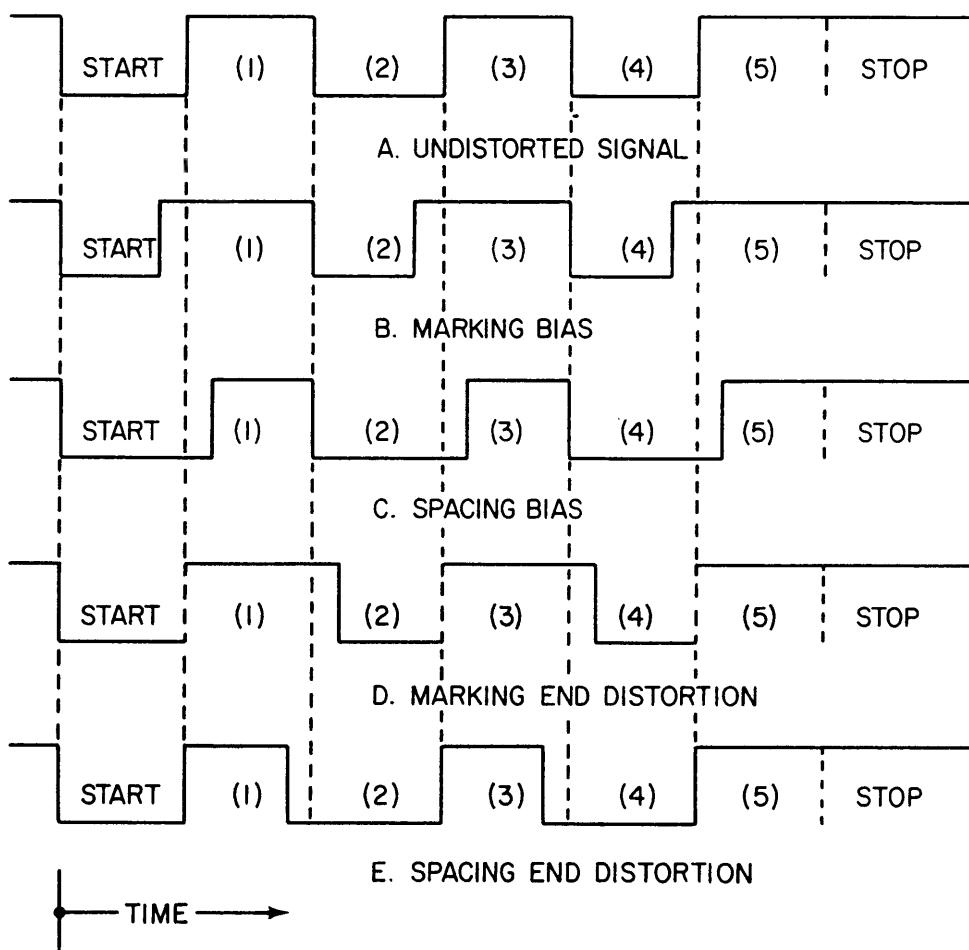
with respect to the initial mark-to-space transition of the start element. These transitions are advanced (early) if the bias is marking, and delayed (late) if bias is spacing.

The nature of bias distortion is such that interchanging the functions of the two current values will change the sign of the systematic distortion, but not its magnitude. In a polar telegraph system, in which marks and spaces are sent by means of currents equal in magnitude but opposite in sign, systematic distortion may be caused by unequal voltages at the transmitting end. If the positive voltage is greater than the negative voltage, the circuit causes the marks to be lengthened when positive current is used for transmitting marks. Conversely, rearranging the system so that negative current is used for transmitting marks

will cause the marks to be shortened proportionately. In systematic distortion, interchanging the functions of the two current values used changes the sign of the systematic distortion, but not its magnitude. The distortion is called bias because a lack of symmetry in the circuit is indicated.

Some of the more common causes of bias distortion are improperly adjusted relays, earth potential differences, leakage currents, unbalance of artificial line on repeaters, and unequal battery tap resistance or potentials.

**END DISTORTION.**—In start-stop operation, end distortion is the shifting of the end of all marking pulses from their proper positions in relation to the beginning of the start pulse (fig. 5-51, parts D and E).



162.199.1

Figure 5-51.—Bias and End Distortion.

If the mark-to-space transitions are delayed, the effect is to lengthen the marking pulses and shorten all spacing pulses. This type of distortion is called marking-end distortion. If the mark-to-space transitions are advanced, the effect is to shorten the marking pulses and lengthen all spacing pulses. This is called spacing-end distortion. It is an artificial sort of distortion, usually deliberately produced for maintenance purposes by a test signal generator.

**CHARACTERISTIC DISTORTION.**—Characteristic distortion is the displacement of signal transitions resulting from the persistence of transients caused by preceding transitions.

This characteristic distortion results from various causes, which are usually different from those associated with bias distortion. Consider a telegraph system in which the sending battery potentials are equal and opposite in sign, and the marks and spaces are formed by corresponding currents, equal but opposite in sign. Also, owing to the characteristics of the given system, the current is slow in building up to the normal mark or space value. If the current does not have time to reach its final value on the short-signal elements, the first mark following a long space may be shortened.

In this case, interchanging the functions of the positive and negative currents will not alter

the dist  
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the sign or the magnitude of the resulting distortion, since the first mark will be shortened whether it is formed by means of a positive or a negative current. This type of distortion is determined by the electrical, magnetic, and mechanical characteristics of the circuit, which are fixed by design.

**CYCLIC DISTORTION.**—Cyclic distortion, which is neither characteristic, bias, nor fortuitous, is periodic in nature. It originates from some defective or improperly adjusted device in the circuit, such as induction from power systems, cross talk from adjacent channels, and arcing of relay contacts at repeated intervals. Cyclic distortion values, when included with other distortion components, should not exceed the margin allowances required for the receiving teletypewriters. Cyclic distortion is illustrated in figure 5-52, parts A and B.

**PEAK DISTORTION.**—Peak distortion defines the maximum displacement of signal train transitions occurring during a measuring period. It does not imply that all signals are distorted by this same maximum value. Peak distortion is illustrated in figure 5-52, part C.

**FORTUITOUS DISTORTION.**—Fortuitous distortion is the individual departure of any one distortion from the average (systematic) distortion of a particular element in a large number of successive repetitions of a signal. It displaces miscellaneous received transitions by various amounts in an irregular manner, regardless of the signal combination. At times, it may be large enough to cause a complete failure of the circuit, or the addition of fortuitous distortion to the systematic distortion already in the circuit may result in an error in the received character. This type of distortion is common in high frequency radio circuits where disturbances

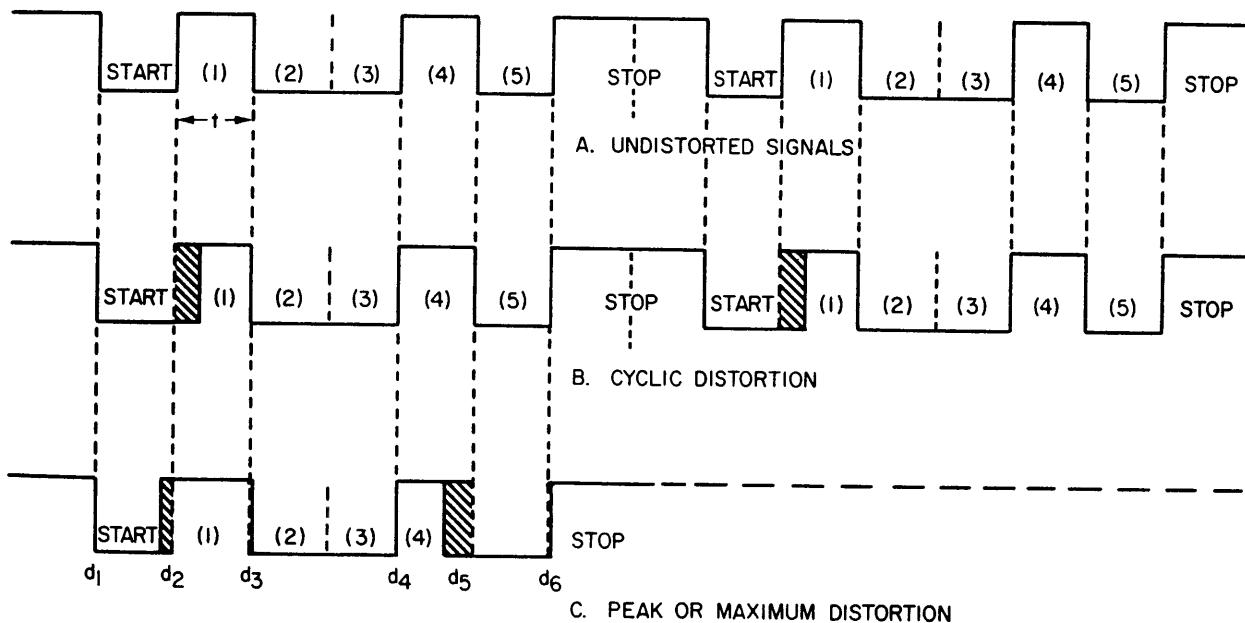


Figure 5-52.—Cyclic and Peak Distortion.

162.199.2

in the transmission media cause irregular reception of signals. Other causes are accidental irregularities in the operation of the apparatus and moving parts, power induction, momentary battery fluctuations, and line disturbances (hits).

### Measuring Distortion

In teletype transmissions a certain amount of distortion can be present without the person at the receiving end being aware of it; that is, he receives good copy. The limits of the teletypewriter to accept distorted signals and still produce the desired characters are called the "margin" of the teletypewriter.

**MARGIN MEASUREMENTS.**—The receiving unit of the teletypewriter machine is equipped with a mechanism whereby the selecting block may be moved throughout the unit segment. This mechanism is known as a "range finder" and is equipped with a scale graduated from 0 to 120. One hundred divisions on this scale represents a movement of the selecting block through a unit segment. This arrangement provides a means of measuring the distortion on received signals.

To measure the total net effect of all kinds of systematic distortion, or the position of received signals, the range finder is first moved in one direction until errors appear in the copy and then moved back slowly until these errors are just eliminated. Similarly, the range finder is moved the maximum distance before errors occur in the opposite direction. These two scale readings then give the operating margin of the signals under test. On perfect signals the margin would be from 10 to 90.

Margin measurements, in addition to showing the distortion present in the received telegraph signals, also show speed differences between the sending and receiving machines. The effect of a slow sending speed is to cause each unit to be greater than 22 milliseconds (60 WPM) and each transition to occur progressively later than it should. The effect on the margin of operation is to raise both limits, the lower limit being raised much more than the upper limit. For example, a margin of 35 to 100 indicates the sending speed is five percent slow.

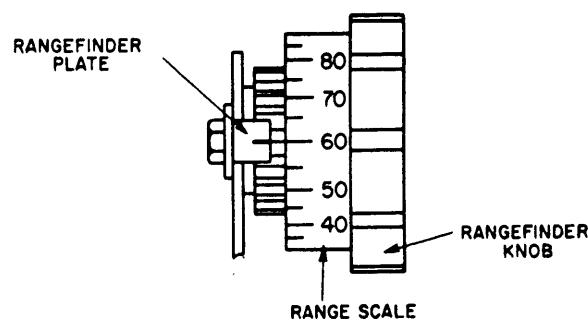
On the other hand, the effect of a fast sending speed is to cause each unit to be smaller

than 22 milliseconds and each transition to occur progressively earlier than it should. The effect on the margin of operation is to lower both limits, the upper limit being lowered much more than the lower limit. For example, a margin of 5 to 60 indicates the sending speed is five percent fast.

### Orientation Range Finder

Figure 5-13 illustrates the signal for the letter "R" in which each unit or element is perfect in every respect. To print the letter R, the selection mechanism could be set to operate on any 20-percent portion of each unit, and perfect copy would result. Under actual conditions, a signal is never this perfect, nor is a teletypewriter expected to operate over the entire range of the unit. Rarely will more than 70 percent of each unit be usable by the selecting mechanism. This means that the selection point must be positioned so that the best portion of the element will be used by the selecting mechanism.

Each teletypewriter is equipped with an orientation rangefinder that allows the machine to be set at the range of best reception. The rangefinder is a device consisting of a scale and a finder knob. (The finder and its scale are illustrated in figure 5-53). Degrees on the scale - 0 to 120 - divide the first unit of the signal only, not the entire signal. When you adjust the finder knob you shift the selection point of the first unit with respect to the



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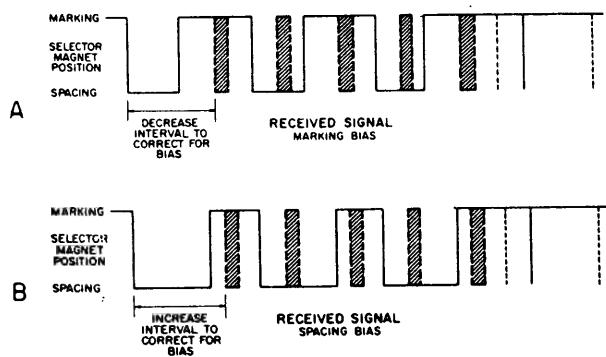
Figure 5-53.—The Orientation Rangefinder.

starting unit. Figures 5-54A and 5-54B illustrate this. Since all other units of the signal follow at a fixed interval, this amounts to an adjustment or orientation of the entire signal to the start pulse.

Since the scale goes up to 120 percent of one unit, you can shift far enough so that the selection interval moves entirely off the unit. If the signal were perfect, you could still shift the finder far enough to produce errors. The object is to place the selection interval on that portion of the unit that will give the selecting mechanism a maximum margin of safety while selecting that unit and the four which follow. With the selection point midway between the transitions, there is the least chance of error.

To determine the range limits, the finder knob is adjusted at the two extreme positions - at the lower and the upper end of the scale. In each case observations are made of the typed record and a reading is taken when about one error is typed per line of copy. This means about one error in 72 characters. Orientation ranges on properly adjusted teletypewriters for different degrees of signal distortion are as follows:

Points	
Very little distortion	80
Moderate distortion	60 - 70
Average distortion	50
Great distortion	Less than 40



1.203.204

Figure 5-54.—Received Signal Marking and Spacing Bias.

The orientation range limits with practically perfect signals and a teletypewriter in good condition should be 15 and 95. In this case, best operating results will be obtained when the finder knob of the receiving teletypewriter is set at the midpoint (55) of this range.

Actually, the orientation range is determined twice: First, range of the machine (local range) is determined, then range of the machine when connected to the line (line range) is determined. Setting of the finder knob is the midpoint of the sum of these two ranges.

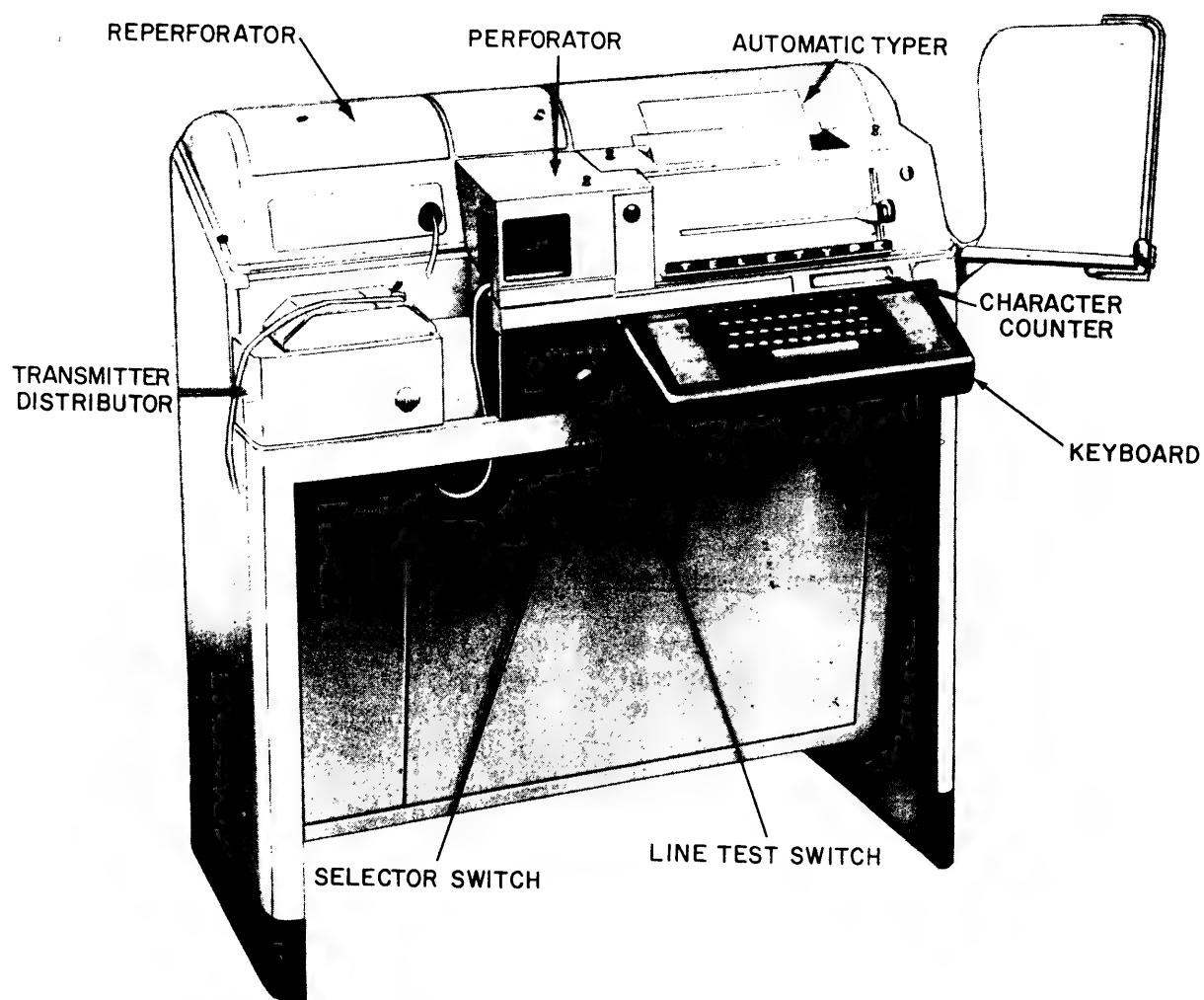
The orientation range is obtained locally by using keyboard signals. Normally, the letters R and Y are used since they give a complete reversal of impulses. R is S-M-S-M-S and Y is M-S-M-S-M.

If the range is not less than about 70 percent (from about 20 to 90 on the scale) it may be assumed that the machine is satisfactory.

The difference between the range determined by local test, and the corresponding range obtained when receiving signals over a line, represents the reduction in margin due to signal distortion. The reduction is a direct measure of total signal distortion.

The manner in which typed errors occur in the neighborhood of the orientation limits may give indication of the nature of the distortion. If limits are fairly definite - the copy changes from good to bad when the rangefinder is moved only a small distance - bias, or distortion due to speed variations or faulty apparatus, is present. If there is a certain range at each limit over which certain characters are consistently in error, this is due to characteristic distortion. If limits are not definite - that is, there is a range over which errors occur, and errors do not occur consistently on certain characters - this is an indication of fortuitous distortion. As a general rule, characteristic and fortuitous distortion cause reduction of the range at both limits. On the other hand, bias affects one range more than the other. Marking bias reduces the upper range limit, and spacing bias reduces the lower range limit.

Maintenance technicians sometimes test distortion tolerance of a teletypewriter by



1.217.13A

Figure 5-55.—Model 28 Automatic Send-Receive (ASR) Teletypewriter Set AN/UGC-49.

applying predistorted signals. This predistortion ranges from zero to 40 percent. A well-adjusted machine will type correctly when signals from a test set are distorted as much as 35 percent.

Rangefinding a teletypewriter is not an everyday occurrence. Usually it is an operation performed in conjunction with maintenance of the machine. Unless something goes wrong with the circuit, rangefinding will be done during overhaul. When range finding a machine, care must be taken that the machine is in good adjustment and range limits are read accurately.

## TELETYPEWRITER SETS

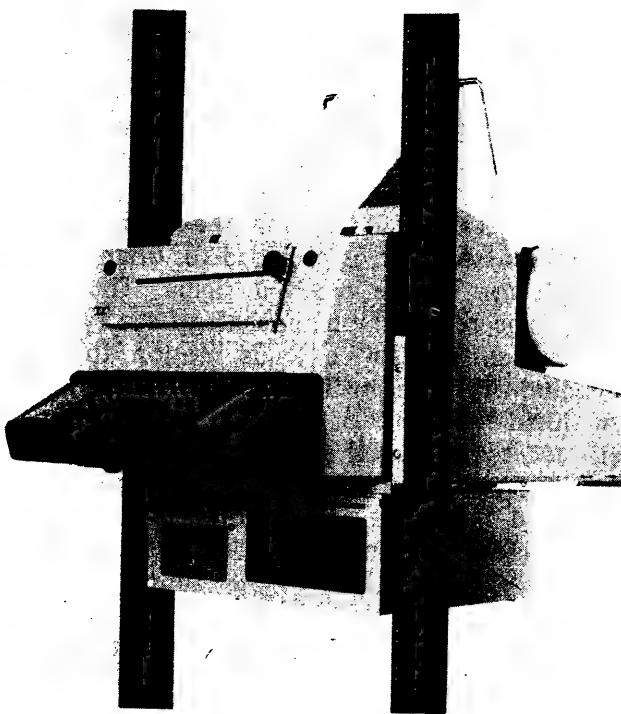
### MODEL 28 TELETYPEWRITER EQUIPMENT

The Model 28 Teletypewriters, described herein, are by far the most common teletypewriter equipment in use by the Naval Security Group today. These equipments are electromechanical devices designed for use with the five-level teletype code. They serve the functions of message printing, message preparation, and message transmission. These functions may all be incorporated into one

composite unit or separate units may be used as required.

The Automatic Send-Receive (ASR) teletypewriter set (figure 5-55) will receive messages electrically and print them on page-size copy paper. It will electrically transmit messages which are originated by perforated tape or keyboard operation, and simultaneously provide a page-printed monitor. It will mechanically prepare perforated and printed tape for separate transmission with or without simultaneous electrical transmission and page printed monitoring. In addition to these functions it will receive messages electrically and record them on tape in both perforated and printed form.

The Keyboard Send-Receive (KSR) teletypewriter set (figure 5-56) will receive messages electrically and print them. It will also electrically transmit messages originated by keyboard operation and simultaneously provide a page-printed monitor. The KSR set may be housed in either a floor model cabinet or mounted in a rack. The Receive-Only (RO) teletypewriter set (figure 5-57) will receive



31.139

Figure 5-56.—Model 28 Keyboard Send-Receive (KSR) Teletypewriter Set AN/UGC-51.



31.140

Figure 5-57.—Model 28 Receive-only (RO) Teletypewriter Set AN/UGC-50.

messages electrically and print them on page-size copy paper. The RO set shown in figure 5-57 is housed in a cabinet for rack mounting.

The typing units used in these sets are designed to handle rolled single copy or multi-copy paper, eight and one-half inches wide. A paper winder is used where needed, to automatically wind the printed copy on a cylinder as it emerges from the cabinet.

Tape used for either perforating and printing messages for transmission or for recording incoming messages is 11/16-inch wide and is supplied in eight inch rolls on a two-inch spool.

The equipment may be geared to operate at various speeds. The most common are 75 bauds per second (approximately 106 words per minute) or 45.5 bauds per second (approximately 65 words per minute) as determined by operational requirements.

There are other transmission patterns which are used in telecommunications. One that is common enough to point out is the 7.42 transmission pattern. The difference between 7.00 and 7.42 transmission patterns is in the length of the last unit (stop unit). The 7.42 pattern has a stop unit length that is .42 unit longer than the other 6 units in the pattern. Formerly 7.42 systems were the most common type; now they are only used in specific areas.

### AUTOMATIC SEND-RECEIVE (ASR) TELETYPEWRITER SET

The sheet metal cabinet (figure 5-55) is designed to house all the components of Automatic Send-Receive (ASR) Set. The upper portion contains the keyboard, typing unit, typing reperforator, transmitter distributor, transmitter distributor base, and motor, also the auxiliary typing reperforator, typing reperforator base and motor.

A dome extending completely across the cabinet is hinged at the rear and latched at both sides. It is partially raised by two torsion bars when the latches are released. Small doors in the dome provide access to components without raising the dome. At the top right end of the dome, a door provides access to the rear of the typing unit for changing copy paper. A window in front of that door affords a view of the platen, type box, and line being typed. The rear of the window is a straight edge for tearing off printed copy. The window may be opened for straightening paper or changing ribbon. A dome door in the center of the cabinet can be opened for reloading the typing reperforator tape container. A hinged segment of the front of the cabinet can be raised for access to the typing reperforator. When closed, this segment has two windows for viewing the perforated tape cutoff guide. A door at the left of the dome provides access to the auxiliary typing reperforator.

The dome is wired to include a 6-volt copy and indicator lamp circuit. Associated with this circuit is a transformer and a three-position toggle switch which is accessible in the center of the cabinet dome when the right dome door is open. Also mounted on the dome are lamps for

illuminating copy in the typing unit, copy paper, and an end-of-line or margin indicator.

Terminal boards for equipment wiring distribution are located across the back panel of the cabinet.

A shelf separates the upper portion from the lower portion of the cabinet and serves as a mount for most of the components. Incoming signal and power lines, and cradle assembly are mounted on the top side of the shelf. The cradle rests on vibration mounts. A switch lever for controlling the power switch on the electrical service assembly extends under the cradle and protrudes at the right of the keyboard.

The lower portion of the cabinet contains the electrical service assembly, for electrical signal processing.

#### Typing Unit

The typing unit, (figure 5-58), a component of each of the sets, incorporates the necessary electrical and mechanical elements to translate the signalling code combinations into mechanical actions which print the messages and perform functions incidental thereto. Code signals are applied to a two-coil RFI shielded magnet associated with a selecting mechanism which interprets the signals and controls the motion involved in typing a character or performing a required function. The range finder, to be discussed later, is provided for orientating the selector to the received signal. The a.c. motor is geared to the main shaft of the typing unit, which in turn, extends motion to the keyboard mechanism. The typing and various functional sections of the typing unit are activated by individual clutches that completely disengage at the termination of each operation cycle and thus reduce the motor load to the minimum during idling.

Paper (single or multi-copy) feeds from a five-inch (maximum) diameter roll mounted on the typing unit, and passes around a platen which rotates vertically but which does not move horizontally. Type pallets are arranged in a small typebox which may be detached for

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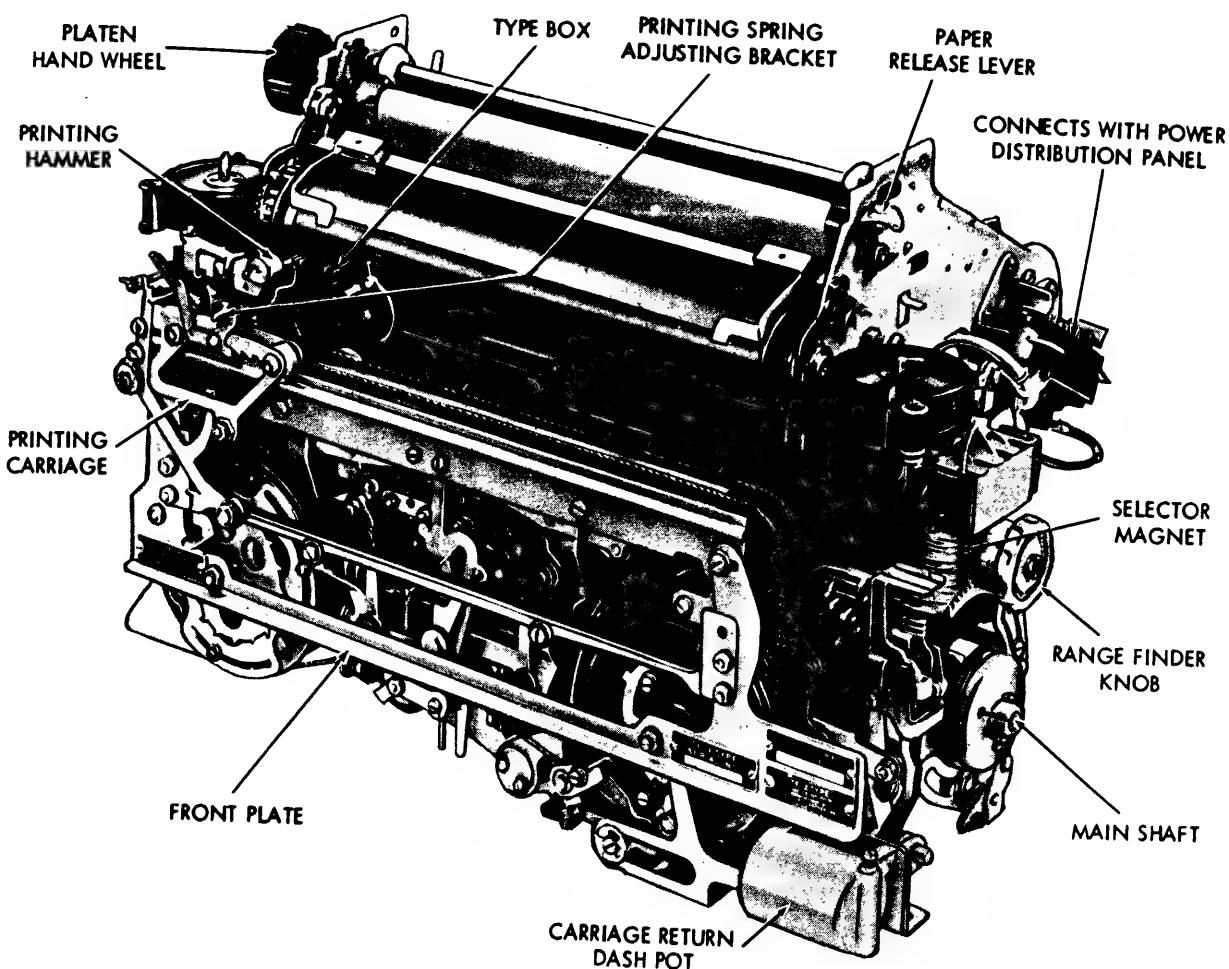


Figure 5-58.—Model 28 Typing Unit (Front View).

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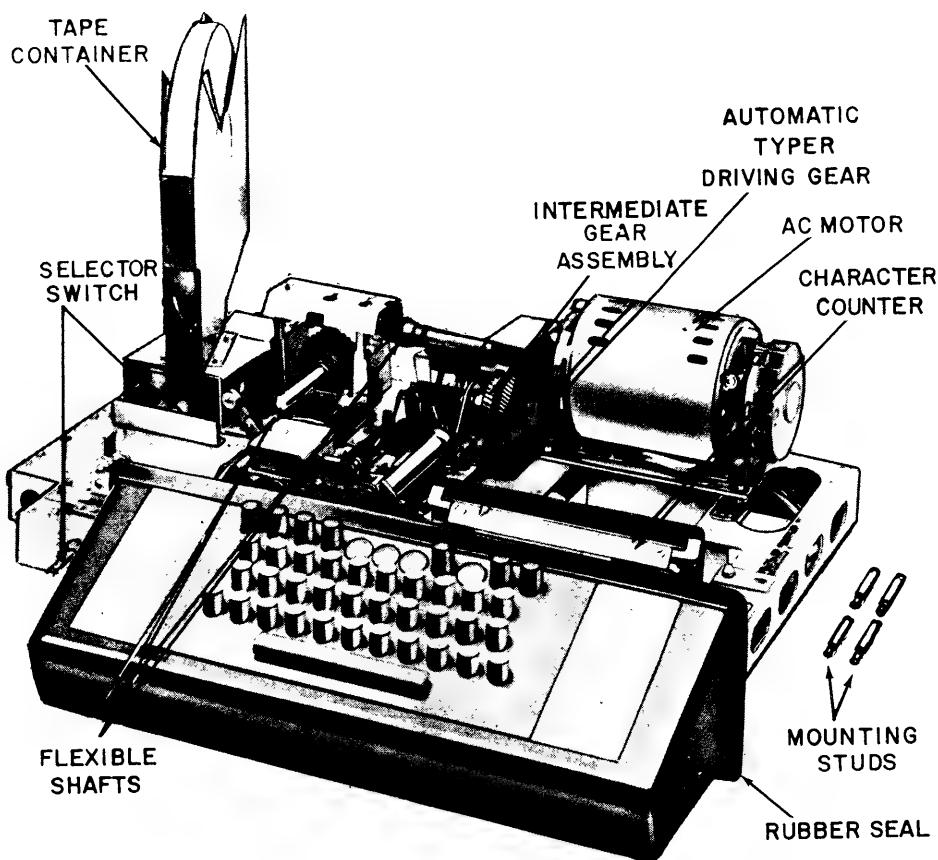
cleaning or replacement. In operation, the type box moves across the paper and presents the proper type pallets to the printing hammer, which drives the pallets and inked ribbon against the paper to print the characters.

In addition to these functions, built-in facilities in the function box permit the addition of selective station call or recognition functions with electrical circuits associated therewith available for remote extension. The typing unit may be stripped of all typing and paper feeding mechanisms and utilized for circuit switching or similar applications.

#### Base/Keyboard

The base or keyboard (figure 5-59) supports the a.c. motor, the typing unit, and in the case of the ASR, the typing reperforator. The keyboard or base is mounted in the cabinet on the rails of a shock mounted cradle. The front of the keyboard or base protrudes beyond the cabinet and is fitted with a rubber gasket that seals the edges of the aperture for silencing effect.

The keyboard for the ASR incorporates code selecting and signal generating mechanisms



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Figure 5-59.—Model 28 Teletypewriter Keyboard Unit.

for synchronous pulsed transmission. Signal line and power line circuits are included. The keys are positioned in the conventional three bank arrangement with numerals, punctuation marks, and special symbols available in upper case positions. Special keys are located directly above the standard keys. The special keys are for local line feed, carriage return, receive, send, and repeat operations. In addition, it has all the necessary elements for the mechanical printing and perforating of tape. The base supports a tape container, a character counter used in connection with the typing reperforator, flexible connections by which rotary motion is imparted to the typing reperforator and transmitter distributor, and a three-position selector switch for determining the mode of operation of the equipment.

### Reperforators

Tape perforation is accomplished by typing reperforators. Typing Reperforators and Auxiliary Typing Reperforators are part of the Automatic Send-Receive Set. The typing reperforator is mounted on its base/keyboard and can be controlled by mechanical linkages on the keyboard or, it can be controlled by the signalling code combinations received from the sending station. The product of the reperforations is identical: a transmissible, five-level perforated tape with printed characters corresponding to the perforated code. The reperforators are similar in appearance, design, and operation with identical subassemblies for the typing and perforating mechanisms. The typing reperforator, mounted on the left front corner of the keyboard, is powered through

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shafts with flexible couplings by the a.c. motor which is mounted on the right rear corner of the keyboard. The auxiliary typing reperforator is powered by a separate driving motor. This reperforator and motor are mounted on a special base located above the transmitter distributor base at the left of the cabinet. It has a power switch, a power line fuse, low tape switch, and a non-interfering letters tape feedout mechanism. The keyboard typing reperforator (figure 5-60) is mounted on, and may be operated through the ASR teletypewriter keyboard. The keyboard typing reperforator records messages on paper tape as printed characters and combinations of perforated code holes. The messages are received from the keyboard in the form of mechanical arrangements which are set up by operation of the keys and are translated by the reperforator

into the necessary mechanical motions to type and perforate the information. With the keyboard selector switch in the K (keyboard) position, the selector switch connects the selector magnet on the typing unit into the signal line circuit of the keyboard signal generator, at the cabinet terminal board, to permit preparation of page copy simultaneously with signal line transmission. In T (tape) position, the selector switch mechanically engages linkages between the keyboard and the keyboard typing reperforator resulting in manual typing reperforator operation independent of the signal line. A jack shaft directly under the typing reperforator main shaft, flexibly coupled to the keyboard bearing bracket mechanism, transmits power required to operate both perforating and typing

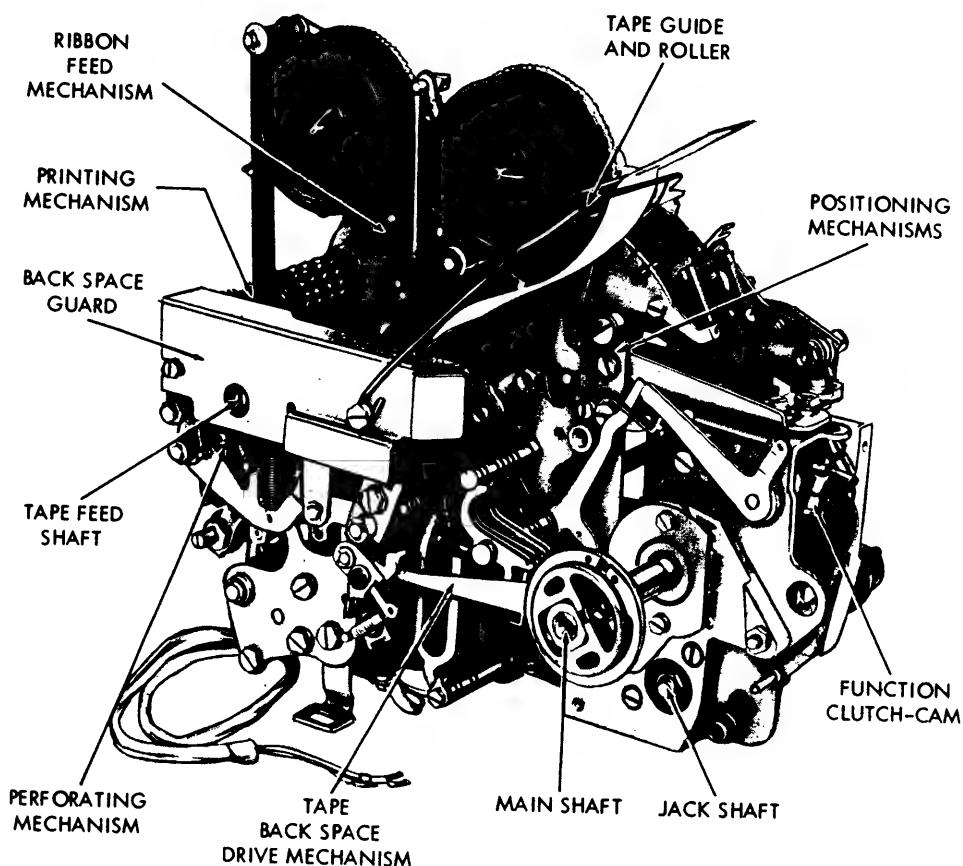


Figure 5-60.—Model 28 Typing Reperforator (Front View).

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mechanisms. A function cam-clutch mechanism keyed to the main shaft and geared to the jack shaft has three cams, two for operation of the rocker bail in K-T and T positions, and the third for resetting the keyboard in T position only. The characters used in printing are embossed on a typewheel which may be replaced to obtain different type faces and character arrangements. Controlled by mechanical arrangements in the keyboard, axial and rotary positioning mechanisms in conjunction with a correcting mechanism select the proper characters by moving the typewheel. A printing mechanism utilizes a hammer to drive the tape and inked ribbon against the typewheel and imprint the selected characters. The ribbon is advanced by a ribbon-feed mechanism. A perforating mechanism steps the tape, perforates feed holes and code holes corresponding to the code permutations established in the keyboard. Printing and perforating occur simultaneously, but the characters are printed six spaces to the right of the corresponding code combinations. The typewheel is retracted at the end of each operation so that the last printed character is visible. In addition to the above features, the reperforator is also equipped with a selector assembly. Messages can be received from the channel in the form of signalling code combinations which are translated into mechanical arrangements to control printing and perforation of tape when the control of the ASR keyboard is in K position. This feature of the unit operates from the signal line in essentially the same manner as the auxiliary unit.

#### Transmitter-Distributor

The transmitter distributor (figure 5-61) mounted on its own base in front of the ASR cabinet dome and to the left, is a mechanical tape reader designed to convert coded messages stored on standard five-level perforated tapes to signalling code combinations for transmission. A main shaft powered by flexible shaft connections from the a.c. motor on the keyboard through an intermediate gear and shaft on the transmitter distributor base, operates a cam-clutch assembly. The cam-clutch, through a

main bail, drives a transfer and signal generating mechanism and a tape feed wheel. The clutch is released by a clutch trip magnet. The unit includes a start-stop switch in which are incorporated tight-tape shut-off, and free-wheeling tape feed features. A second switch shuts off the equipment automatically when tape runs out. Electrical requirements of the transmitter distributor are supplied by way of the terminal blocks in the ASR cabinet through a connector on the transmitter distributor base. Transmission speed can be at 45.5 or 75 baud depending upon the gear ratios used.

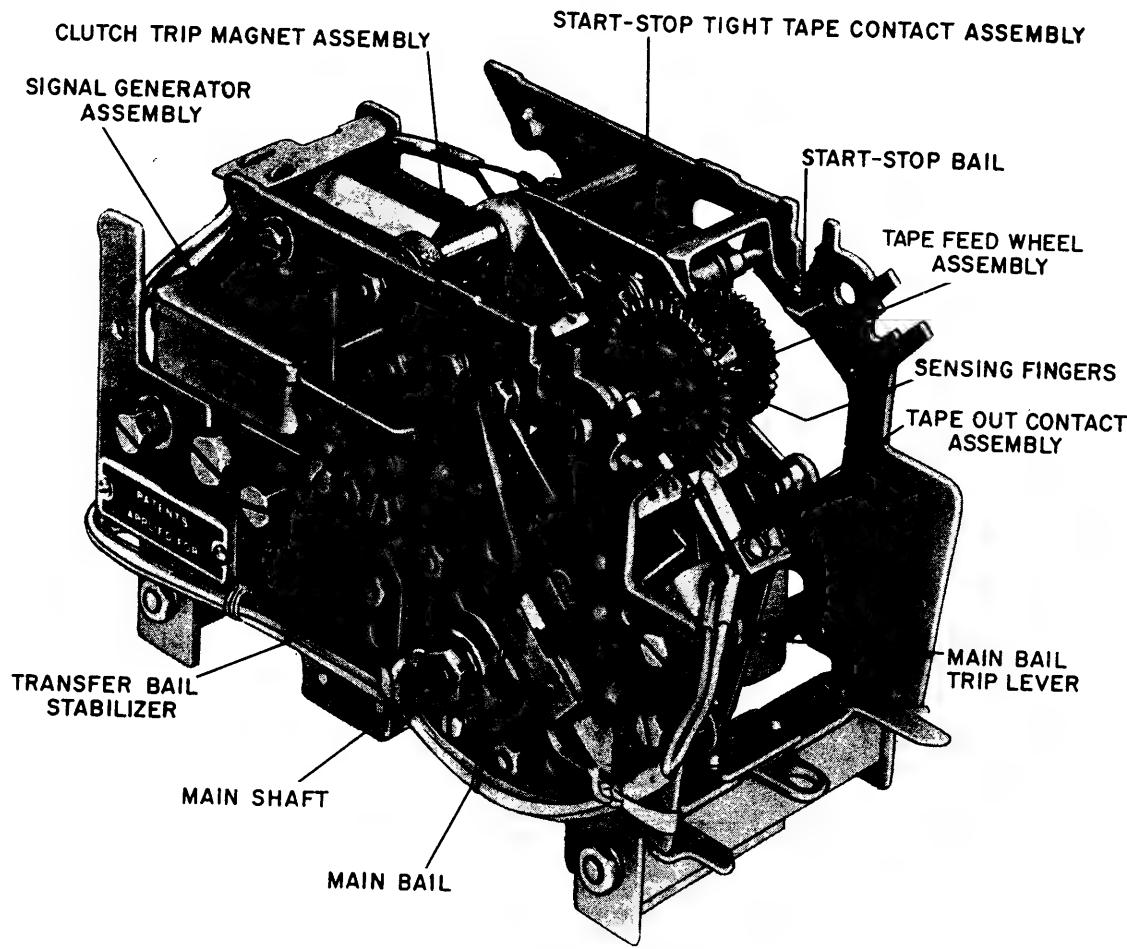
The Transmitter Distributor Base provides mounting facilities for the transmitter distributor. It is a casting mounted on rubber silencing bushings on the left side of the cradle in the ASR cabinet. An intermediate gear assembly connected by flexible shaft couplings to the keyboard mounted a.c. motor is located on the rear of the base. An electrical connector and cable are assembled on the right side of the base. A ground strap is provided for connection between the LCXB Base and the cradle of the cabinet, since the base is electrically isolated from the cradle by the rubber silencing bushing. The transmitter distributor is mounted at the front of the base, projecting beyond the cabinet dome.

#### Motors

The motors are self-contained components mounted on the base/keyboard or on the auxiliary typing reperforator base. The LMU 3 and 4 motors are used to supply mechanical energy for the auxiliary typing reperforator in the ASR set or for the typing unit in the KSR or RO Sets. The LMU 12 and 14 motors are heavy duty motors used to drive the typing unit, keyboard, typing reperforator and transmitter distributor in the ASR Set. Both the light duty and heavy duty motors are furnished for a.c. synchronous or a.c. governed operation.

**A.C. SYNCHRONOUS MOTOR LMU3** (figure 5-62).—This motor is mounted at the rear of the base or keyboard in the RO and KSR Sets

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Figure 5-61.—Transmitter Distributor (cover plate, top plate, and tape guide plate removed).

and under the auxiliary typing reperforator base in the ASR Set. It supplies rotary mechanical motion to the main shaft of the typing unit or to the main shaft of the auxiliary typing reperforator through intermediate gears. The unit is a 1/20 hp, 115 volt, 60 cycle a.c., single phase, capacitor start synchronous motor which runs at 3600 rpm. The motor has a two-pole wound stator and a squirrel cage type rotor which is mounted on ball bearings. The stator has a start winding and a run winding. The starting capacitor and relay and a thermal cutout switch are mounted in a compartment under the motor. The motor is supported by a cradle to which it is held by straps at each end. Resilient

mounts on the hubs of the motor end bells reduce transmission of vibration. A combination handwheel and fan is mounted on one end of the motor shaft. The motor shaft turns in a counterclockwise direction as viewed from the fan end.

A.C. GOVERNED MOTOR LMU4 (figure 5-63).—The LMU4 governed motor is similar to the synchronous motor in location and mounting function. The unit is a 1/20 hp, 115 volt, 50-60 cycle a.c. governed motor which runs at a governed 3600 rpm. A combined governor and fan are mounted on a motor shaft, which is supported on ball bearings. An

**A. C. SYNCHRONOUS MOTOR LMU12.**—This is a heavy duty motor used to supply rotary motion to the main shafts of the typing unit, keyboard, typing reperforator and transmitter distributor in the ASR Set. It is a 1/12 hp, 115 volt, 60 cycle a.c., single-phase, capacitor start synchronous motor which runs at 3600 rpm. It is identical in appearance and mounting requirements to the LMU3 motor.

**A.C. GOVERNED MOTOR LMU14.**—This unit is a 1/15 hp, 115 volt, 50-60 cycle a.c. governed motor which runs at 3600 rpm. It is identical in appearance and mounting requirements to the LMU4 motor. Since it is a heavy-duty motor its application is the same as the LMU12.

#### Electrical Service Assemblies

Several different types of electrical service assemblies (ESA) are now in use, however, the functions are the same. The ESA used with the low-level ASR, KSR, and RO unit is completely RFI shielded, and contains the main a.c. power switch, motor switch fuses, electronic keyer circuit boards, and other components associated with the power and signal line circuits. The high level ASR's, KSR's, and RO's which have been low-level modified also use this ESA. Some exceptions may be noted as the low-level modifications were of a temporary nature awaiting future upgrading.

The low-level ESA is located in the lower section of the low-level ASR (including modified high-level sets). These units are interconnected with other components of the teletypewriter set by way of the terminal blocks and direct shielded cabling.

The high-level ESA is the same in function, however, it is not shielded; incorporates different types of keyers, and is mounted in the upper portion of the high-level ASR directly behind the keyboard. Both the high-level and low-level ESA's used with the KSR and RO sets are housed in separate containers for rack mounting.

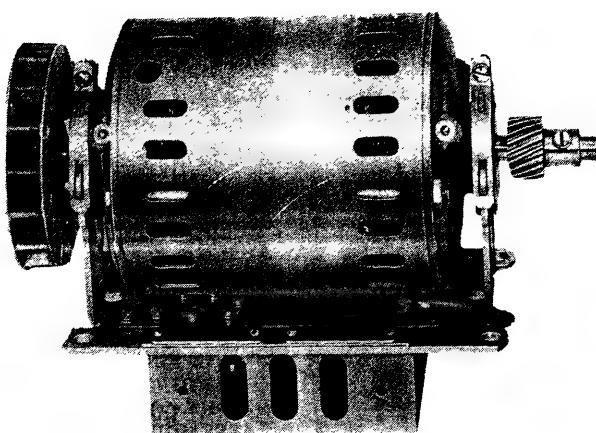


Figure 5-62.—A.C. Synchronous Motor LMU3.

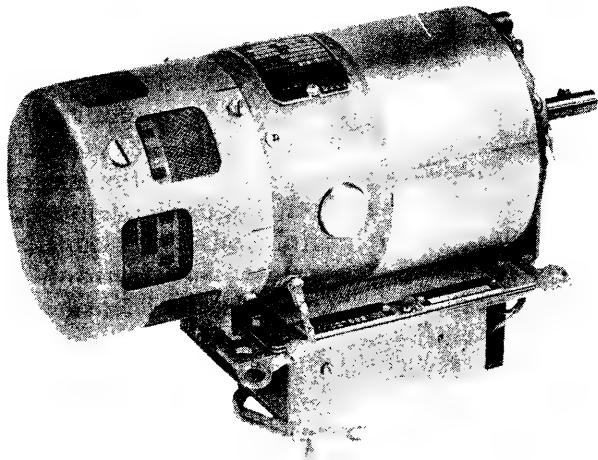


Figure 5-63.—A.C. Governed Motor LMU4.

electro-mechanical governor is wired in series with the armature and two field windings. Targets for speed checking are marked on the governor cover. The entire motor is shielded to minimize radio interference. A shielded compartment on the underside of the motor houses the governor resistor and capacitor, as well as an electrical noise suppressor across the power leads.

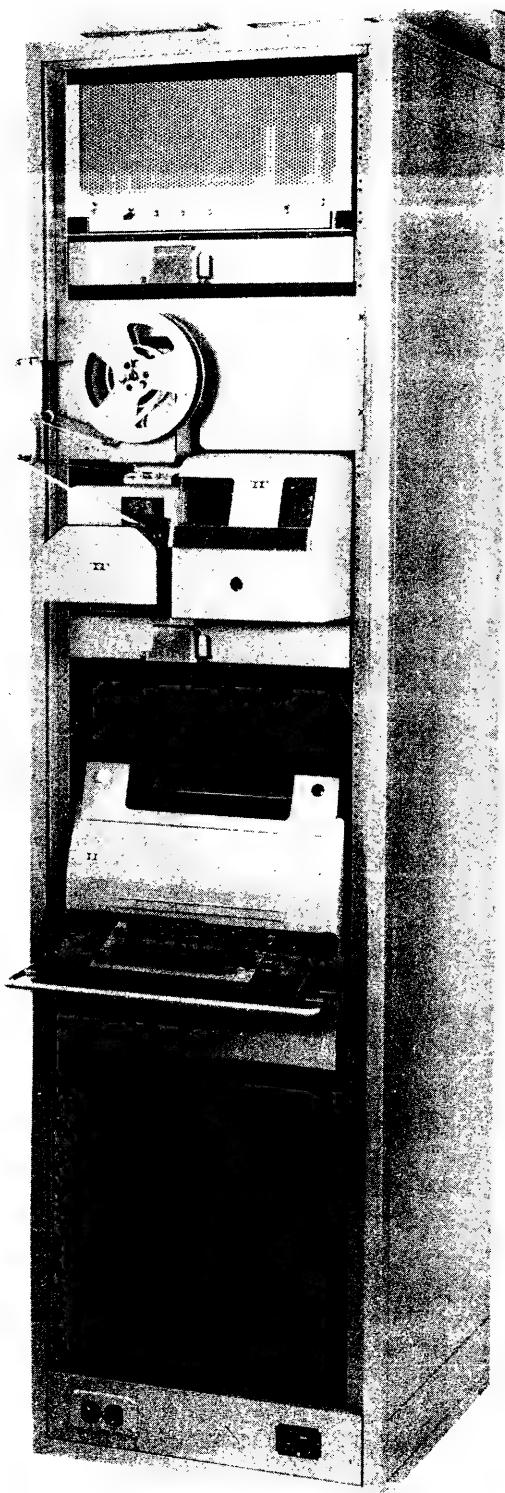
**HIGH-LEVEL ELECTRONIC KEYER.**—The signal applied to the selector magnets must be neutral keyed direct current, nominally 0.035 ampere, when the polar signal line is “marking.” The electronic keyer in the electrical service assembly repeats the incoming polar line signals in a neutral local loop to the selector coils of the receiving unit. A rectifier in the electrical service assemblies supplies operating current to the local loop. The input signal to the keyer is a polar signal of 60 volts. Transmission signal line current must be furnished from an external rectifier.

**LOW-LEVEL ELECTRONIC KEYER.**—The low-level electronic keyer functions similar to the high-level keyer. This keyer is transistorized, and housed within the ESA for RFI suppression. The input signal to the low-level keyer is a polar signal of 6 volts d.c.. All signal output to the receiving units are connected directly by shielded cables to maintain RFI suppression.

### MODEL 35 DATA PREPARATION SET

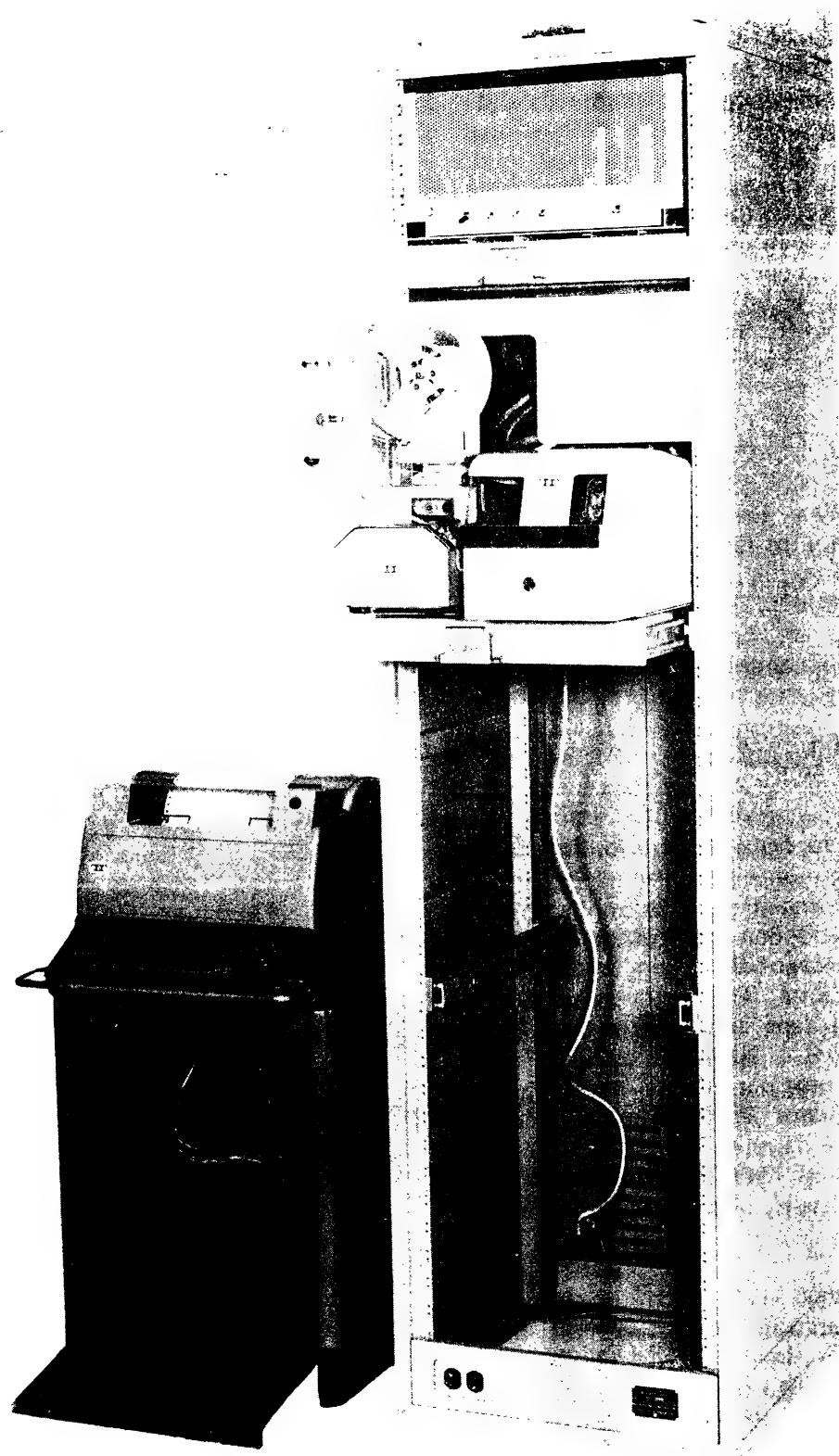
The Model 35 Data Preparation set is the first of two common eight-level teletypewriter sets described in this manual. As implied by its name, the model 35 data preparation set is used for eight-level message origination, reproduction, and retransmission. The set prepares an eight-level ASCII tape and/or page copy from data inserted from a keyboard or an external source at 100 words per minute. An eight-level transmitter-distributor is provided for use in tape regeneration. The prepared tapes are used for transmission of data to distant terminals, local computer inputs, and other data oriented functions.

There are three different configurations of the data preparation set. Two of these configurations are shown in figures 5-64 and 5-65. All three configurations are comprised of the same basic components: a keyboard, a typing unit, a transmitter-distributor, a non-typing reperforator, a tape winder, and an electrical service assembly. One configuration has the exception of a tape winder in the place



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Figure 5-64.—Model 35 Data Preparation Set, VCL-356.



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Figure 5-65.—Model 35 Data Preparation Set, VCL-358.

of the transmitter-distributor. This configuration is not shown.

The keyboard (figure 5-66) generates a sequential and parallel signal output from any one of the keys of the keyboard arrangement. Four rows of keys are presented to the operator. The shift keys and the control key do not generate a code permutation but instead operate a mechanical logic within the keyboard mechanism. Four functional keys are also available for use. These are: local carriage return,

single line-feed, local line-feed, and single reverse line-feed. Control and repeat keys are not installed on the keyboard as received from the factory, however, they are provided for use if desired.

This keyboard will generate, with even parity, assigned permutations of the ASCII code except the overscore inhibit (OI) character.

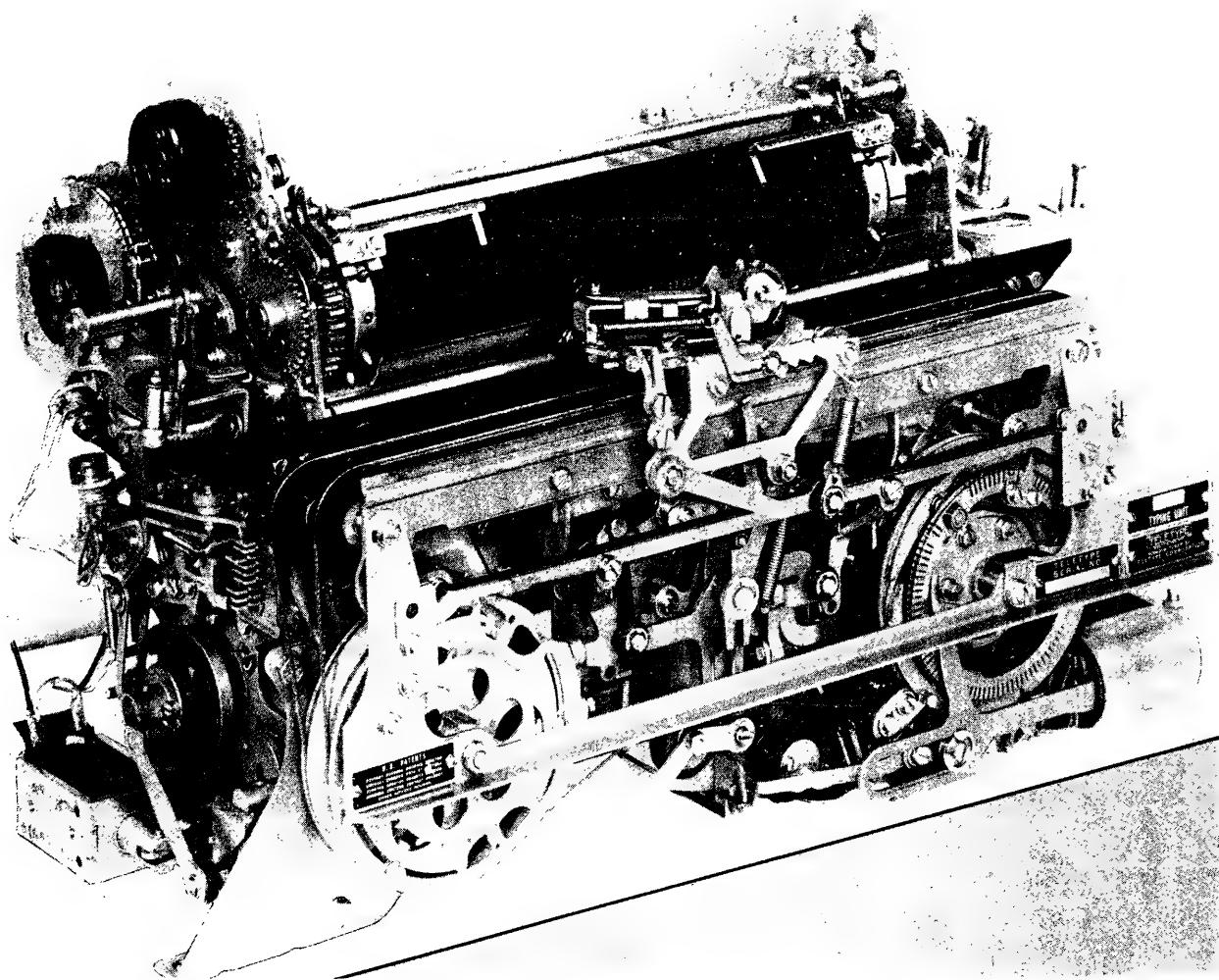
The keyboard provides a low-level signal generator using gold-plated contacts plus a filter network for generating a start-stop code pulse



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Figure 5-66.—VCL-804 Keyboard Without Typing Unit and Cover.

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Figure 5-67.—Model 35 Typing Unit (Front View).

with RFI suppression. A low voltage (3 volts, 70 microampere) is used in the series signalling applications, although a higher voltage may be used.

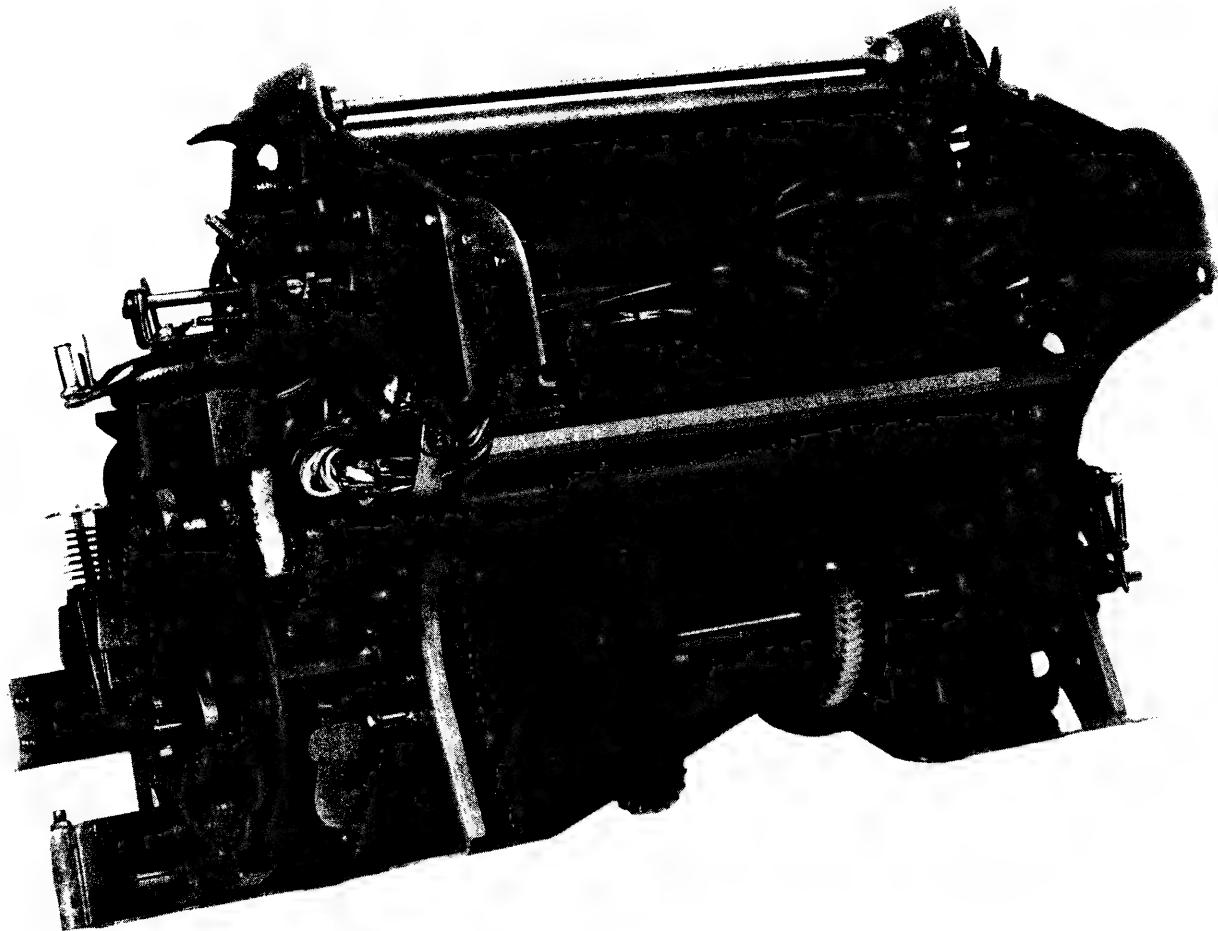
The keyboard mechanism is attached to a box frame with provisions for mounting a page printer, motor, and parallel distributor. This keyboard mechanism can be recognized from earlier versions by the presence of the number eight code bar, a control lockbar, a special carriage return bar, and a shift lock bar.

The typing unit (figures 5-67 and 5-68) works on the same principle as the model 28,

with the exception that this unit is adapted to use the eight-level ASCII code, and incorporates a storage mechanism to delay the printing of the input character until approximately the time the number 7 bit of the following character occurs.

This typing unit uses sprocket-feed paper and receives 8-level, 10-unit code at 100 words per minute. The number 8 bit is assigned to parity, but, does not function or control the printer.

The non-typing reperforator (figure 5-69) receives parallel signals from the keyboard,



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Figure 5-68.—Model 35 Typing Unit (Rear View).

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transmitter-distributor, and from an external 24-hour timer via the time sequence generator. These signals are converted into mechanical motions to perforate a tape. The tape can then be stored and the information retransmitted at some later time. When used simultaneously with the typing unit, the reperforator receives information at a maximum rate of 100 wpm. When operating alone, the reperforator can receive information at a maximum rate of 200 wpm.

The transmitter-distributor (figure 5-69) accepts one inch wide, 8-level ASCII perforated tape, and provides an 8-level, 10-unit, 100 wpm sequential output signal. A parallel signal output

is also available from code reading contacts which operate indirectly from the tape sensing pins. This unit is designed for low-level operation, but may be operated at high voltages.

The electrical service assembly (figure 5-70) contains the power supplies, low-level keyer, relay bank, time sequence generator, and various electrical connectors for control and distribution of the signal and power voltages.

#### MODEL 37 KEYBOARD SEND-RECEIVE TELETYPEWRITER SET

Due to increased usage of digital data processing equipment by NAVSECGRU

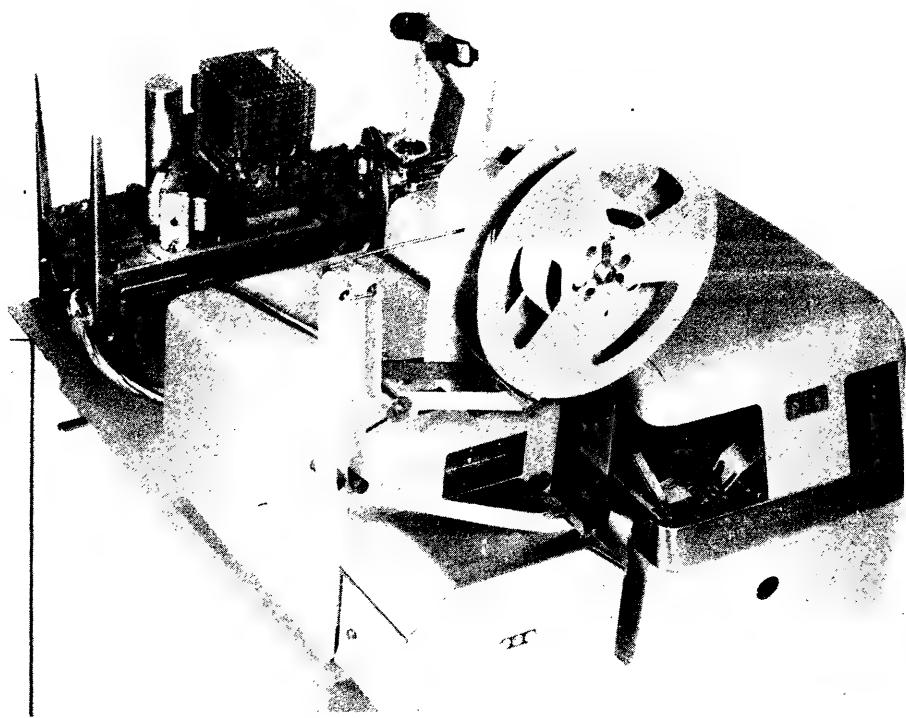


Figure 5-69.—VCL-803, Transmitter-Distributor and Reperforator.

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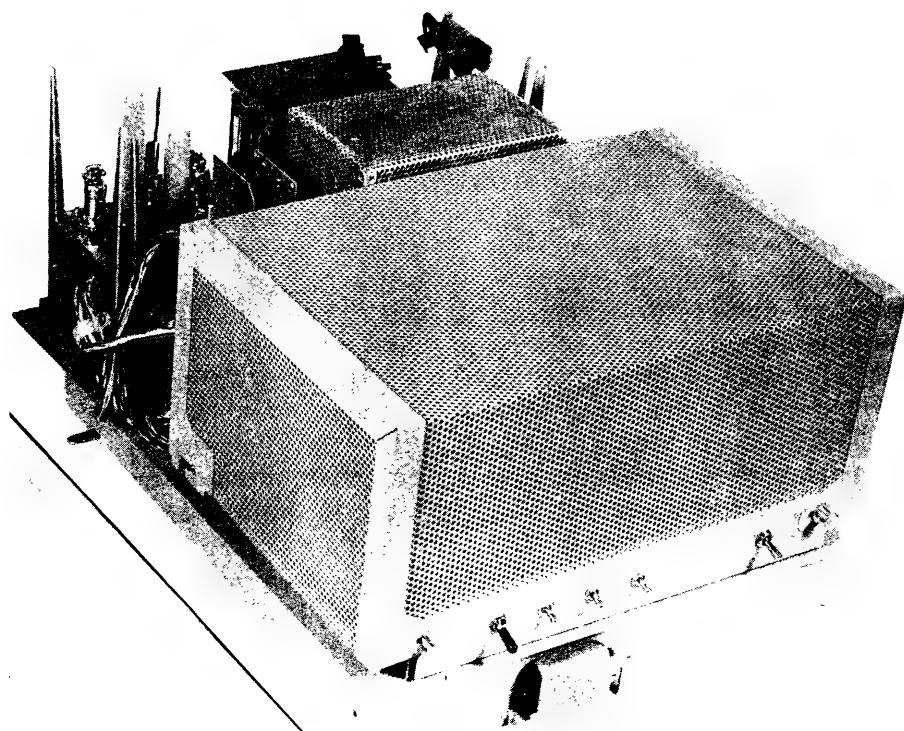


Figure 5-70.—VCL-805, Electrical Service Unit (ESU).

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components, the model 37 keyboard send-receive set (KSR) (figure 5-71) has come to be a common equipment in the field. The KSR-37 is a communications terminal equipment capable of communicating with other identical units, special computer message controllers, or similar equipment. This set accepts even-parity 8-level ASCII coded message data at a rate of 150 wpm for print out by the printer. It will transmit message data to the line from the keyboard at the same rate. It is a send-receiver half-duplex set which sends or receives separately. The interface signals are

shaped low-level signals and meet the interface requirements of MIL-STD-188C. The set is composed of two major components. One is the console, which includes the printer, keyboard, base and enclosures. The other is the electrical service unit, which houses the interface module, logic and control module, and associated power supplies.

#### Keyboard

The keyboard (figures 5-72 and 5-73) is similar in appearance to the model 35 keyboard

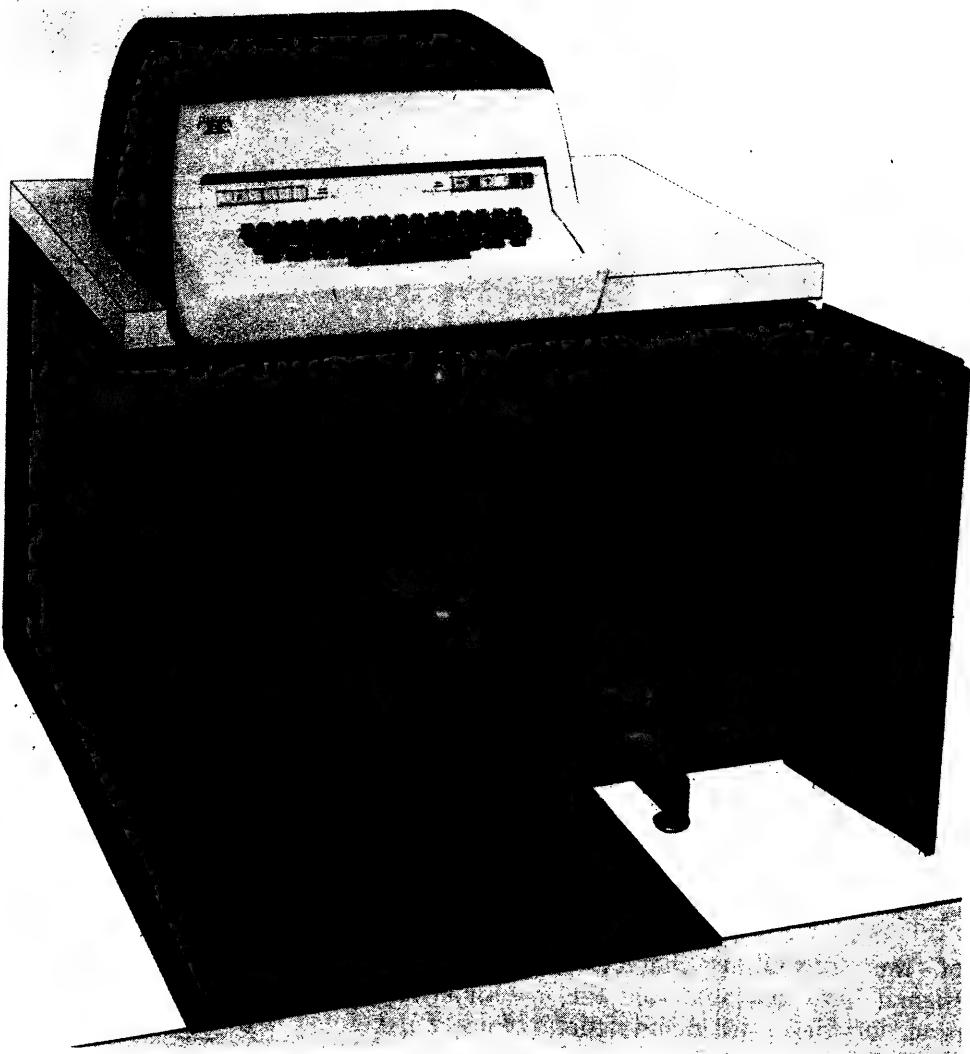
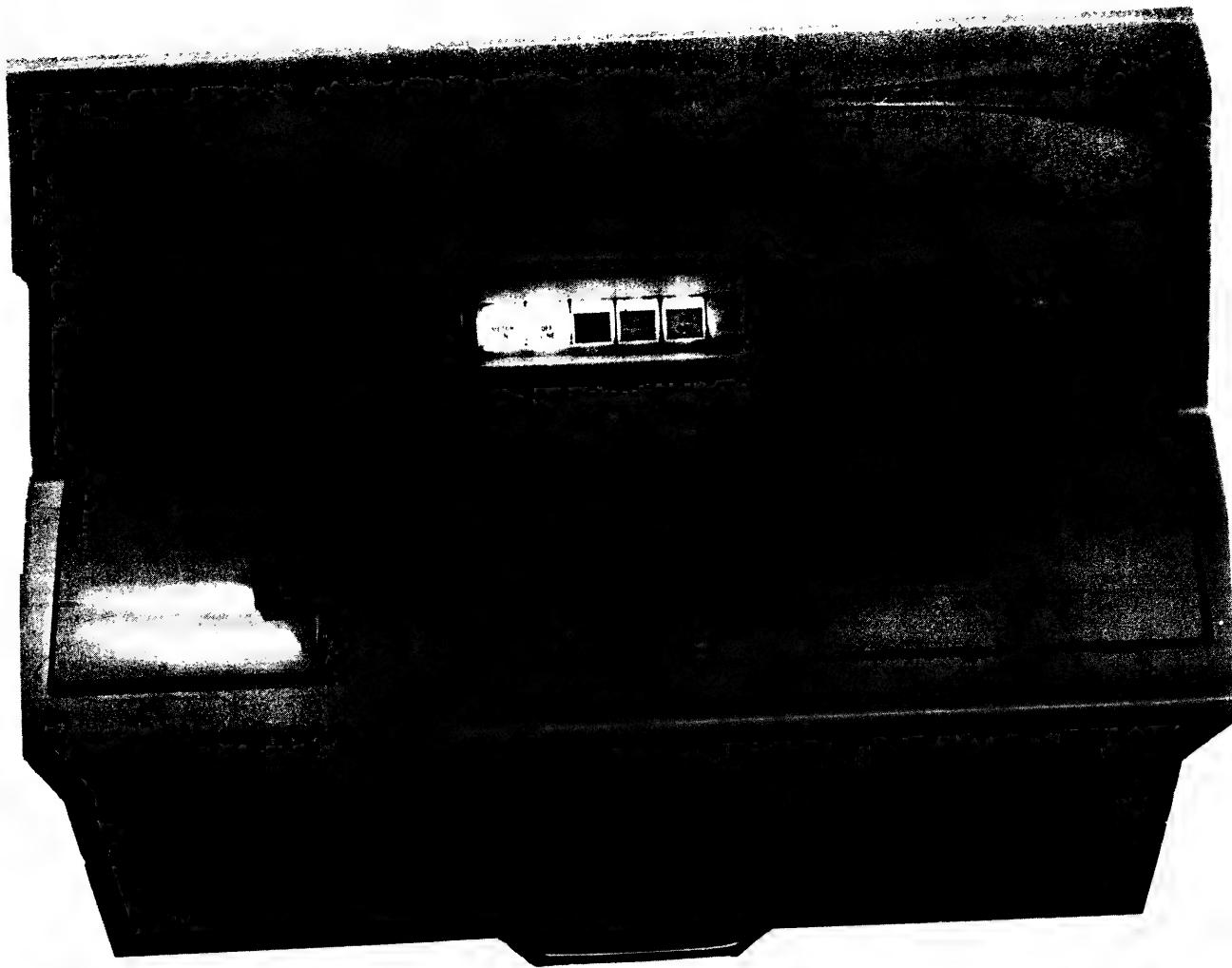


Figure 5-71.—Model 37 Keyboard Send-Receive (KSR) Set.

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Figure 5-72.—KSR-37 Control Panel and Keyboard (Front View w/Cover on).

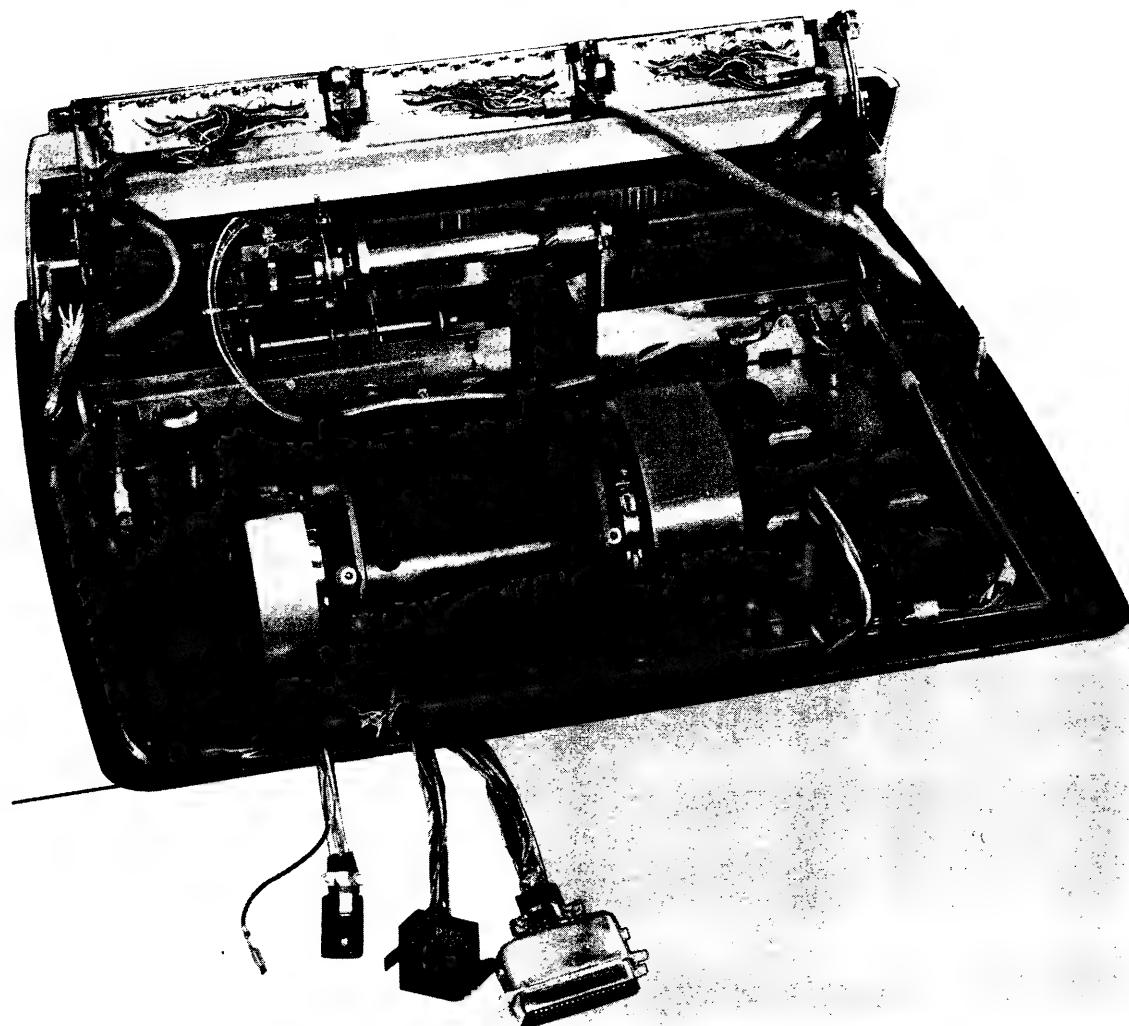
in that it utilizes 4 rows of keys. The KSR 37 keyboard provides a sequential even-parity 8-level ASCII code signal output through electrical switching circuitry. The control key is not supplied or used with the KSR 37.

Fifty-seven of the sixty-three characters (figure 5-74) assigned are available on the typebox for printing. Of these, 40 include the alphabet, numerals 0 through 9, and 4 punctuation marks. The remaining 17 are assigned as control and special characters.

#### Printer

The printer (figures 5-75, 5-76, and 5-77) contains the basic mechanisms for printing a message or performing a function. Rotational motion is applied to the main shaft assembly for distribution to all mechanisms within the unit, and is extended to the keyboard reset coupler for driving a separately mounted, keyboard reset mechanism.

The 8-level ASCII code is accepted by the printer at the rate of 150 wpm (150 baud). Although greatly altered in comparison to the



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Figure 5-73.—KSR-37 Keyboard and Motor Unit (Rear View without Cover).

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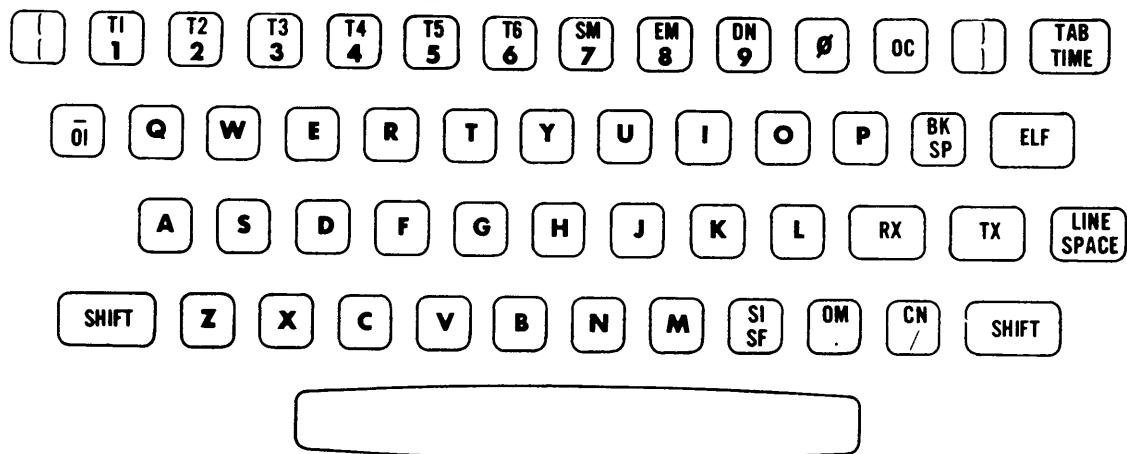
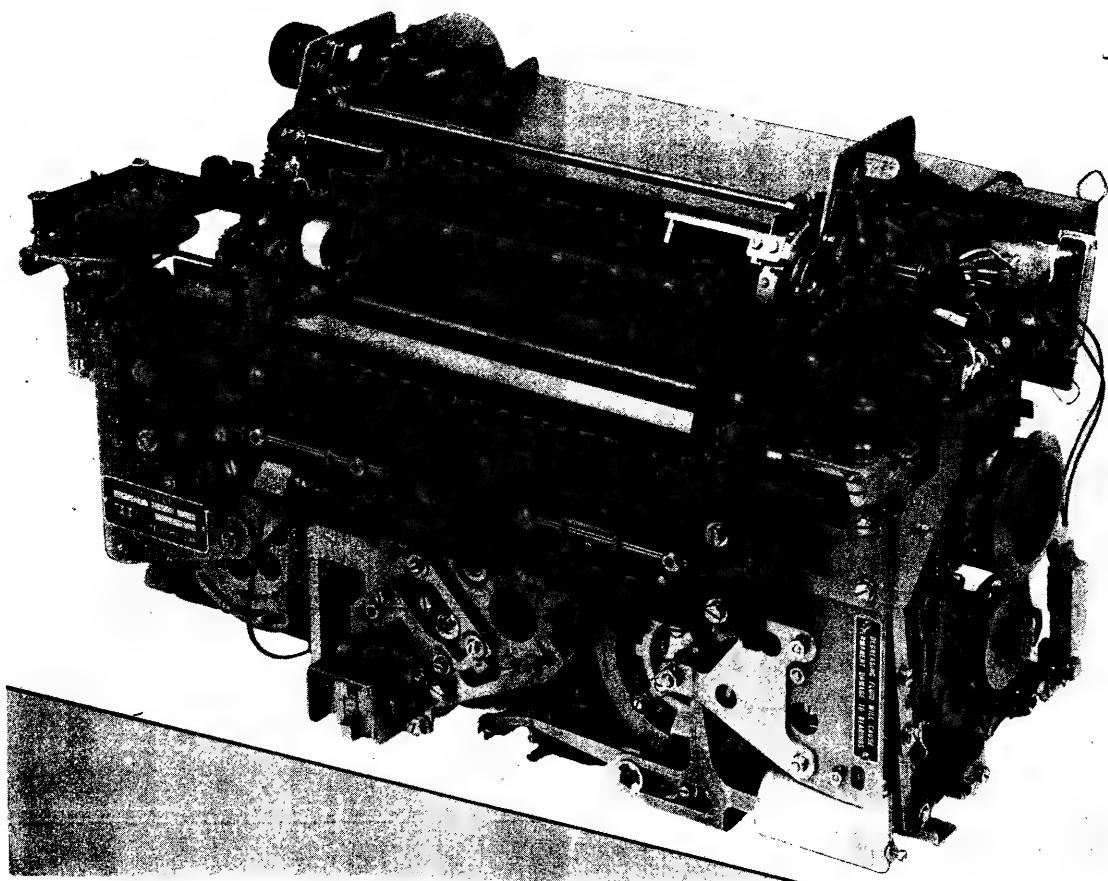


Figure 5-74.—Model 37 Keyboard Layout.

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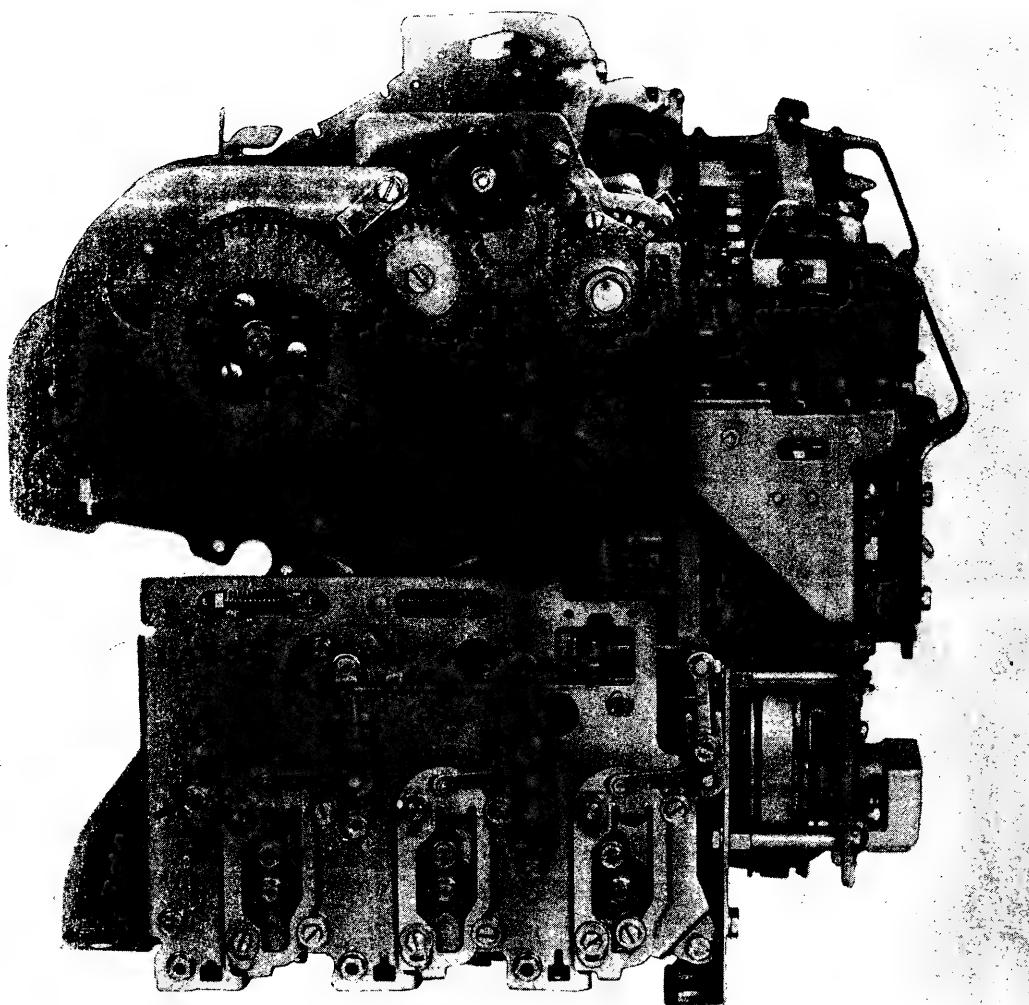


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Figure 5-75.—Model 37 Printing Unit (Front View).

model 28 printer, the model 37 printer functions in the same manner. Some of these differences are noted in additional functions performed by the model 37 printer. As will be noticed, the horizontal and vertical positioning mechanism is extensively reworked to allow positioning of additional rows of type pallets incorporated on the typebox. The keyboard reset coupler, located on the front plate of the printer, is unique to the KSR 37 and functions as described above. A retraction mechanism is used on the KSR 37 printer to lower the typebox for exposure of the printed message after a brief idle time. Its operation repositions the code bars. Another alteration is in the selector mechanism and transfer linkage. The KSR 37 selector/transfer linkage mechanism incorporates a delay mechanism to delay

printing of the received character until approximately the seventh bit of the following character is received. Three optional features which may be encountered in the field are horizontal tabulation, vertical tabulation, and a two color ribbon mechanism. The horizontal tabulation mechanism positions the print hammer and typebox mechanism horizontally when released by a function bar. This positioning is controlled by adjustable index tabs. The horizontal tabulation mechanism is located on the front plate of the printer. The vertical tabulation mechanism line feeds the form when released by a function bar. As with the horizontal tabulation mechanism, it is controlled by adjustable index tabs. The vertical tabulation mechanism is located on the left side frame of the printer. The two-color ribbon



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Figure 5-76.—Model 37 Printing Unit (Left Side View).

mechanism is magnet operated through the function mechanism to shift vertical position of a two-color ribbon. This mechanism is located on the right side frame. All of these optional features are on-line controllable.

#### Electrical Service Unit

The KSR 37 electrical service unit (ESU) (figure 5-78) is mounted in the lower left portion of the KSR cabinet. The ESU provides for circuit cards that contain logic for the set controls, component controls, and power supply regulator. Modular design provides a variety of

circuit arrangements and the ability to add variable features. An associated utility strip provides a.c. power distribution, circuit breaker, relays, and signal bell for the set.

The ESU contains circuit cards for the following functions: mode control, channel control, receive control, receiving device, keyboard control, and alarms and control.

**MODE CONTROL** card—Provides either local or on-line condition for the set. Also provides a clock pulse 32 times the bit rate which is used to control other circuitry in the set.

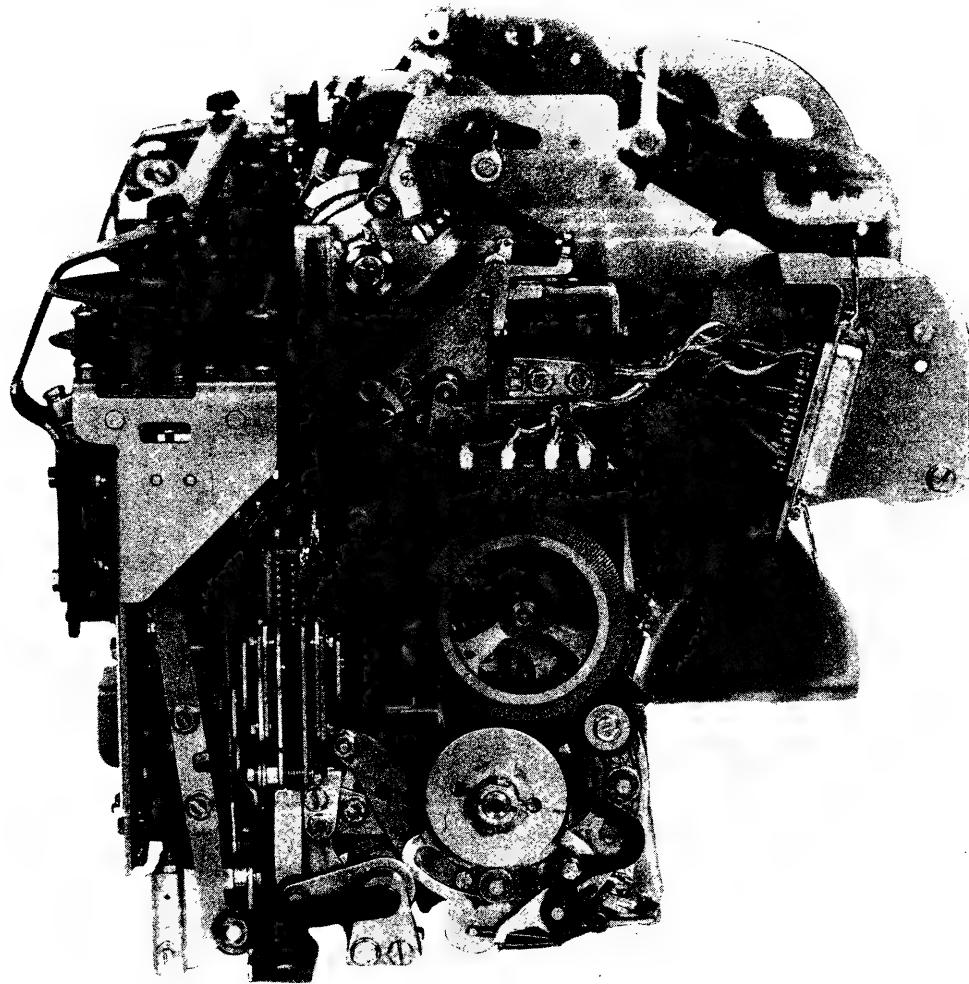


Figure 5-77.—Model 37 Printing Unit (Right Side View).

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**CHANNEL CONTROL** card—The receive and mode control circuits interact with the channel control circuit to govern the on-line mode of the set.

**RECEIVE CONTROL** card—Directs and controls line data signals to the receiving device.

**RECEIVING DEVICE** card—Performs the function of a selector magnet and motor control relay driver.

**KEYBOARD CONTROL** card—Converts the parallel output from the contacts on the keyboard to an 8-level ASCII code.

**ALARMS and CONTROL** card—Supplies power for the signal bell and provides control logic for the paper alarm.

The unit also provides the necessary facilities, power supply wiring, and cabling to convert the KSR set to an ASR set.

#### TAPE RELAY TELETYPEWRITER EQUIPMENT GROUPS

##### Transmitter Group TT-310 of AN/FGC-59

The Teletype Model 28 Transmitter Group TT-310 (figure 5-79) transmits from perforated tape to the outgoing signal lines at 75.0 baud.

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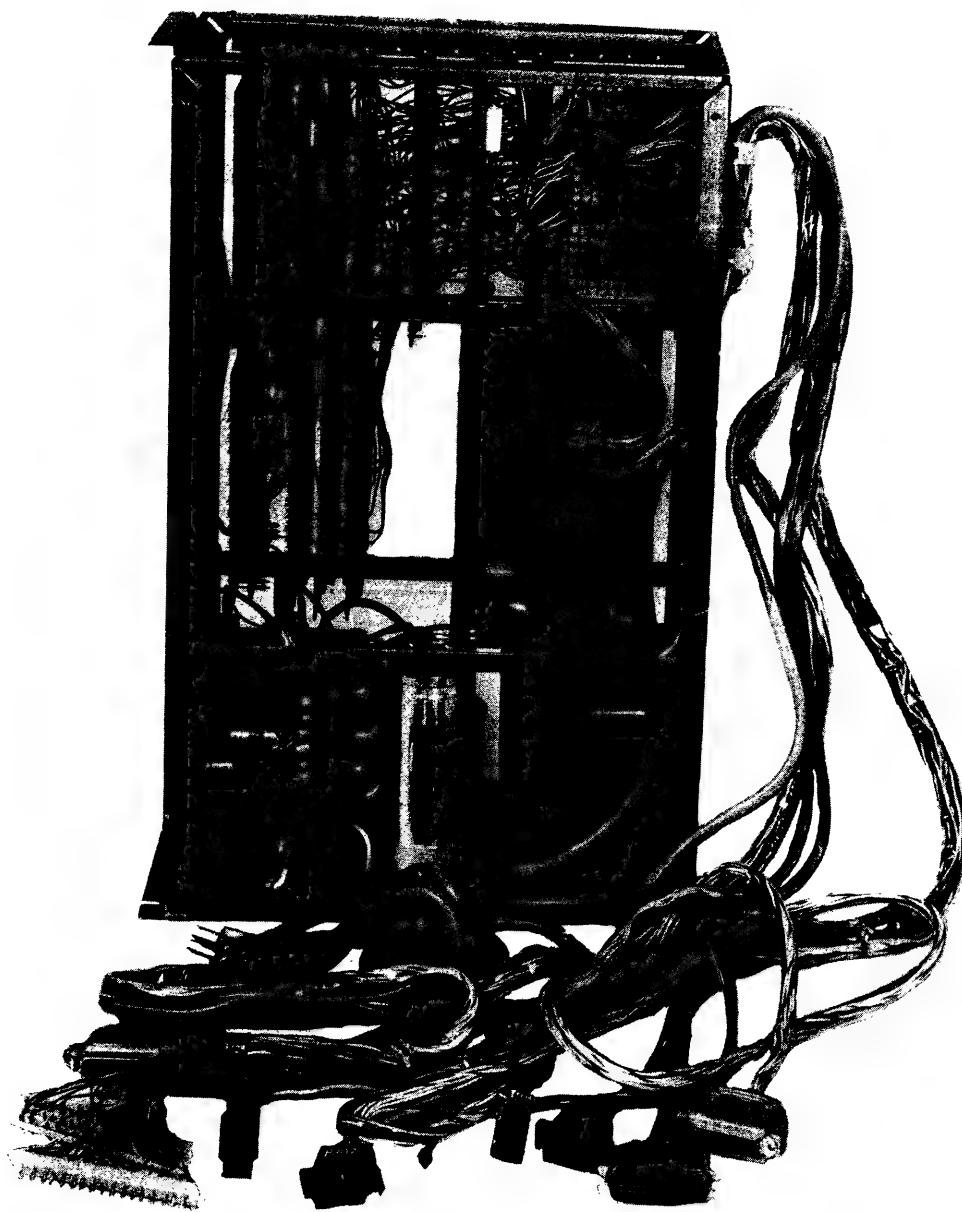


Figure 5-78.—Model 37 Electrical Service Unit (ESU).

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This group provides message numbering, wiring and electrical control facilities to operate three multiple mounted Transmitter Distributor Units in parallel with three other multiple mounted transmitter distributor units. Each of the parallel units is automatically switched into the signal line when the primary TD senses the end of tape.

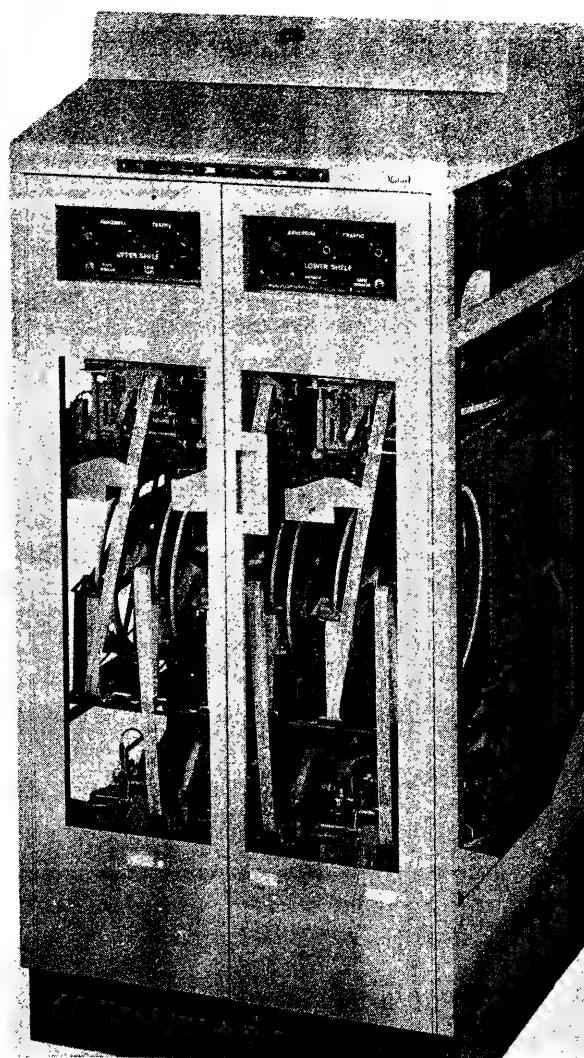
**Typing Reperforator Monitor  
Group TT-309 of  
AN/FGC-59**

The Teletype Model 28 Typing Reperforator Monitor Group (figure 5-80) records the messages, sent out by the transmitter



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Figure 5-79.—TT-310 of AN/FGC-59 Transmitter Group.



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Figure 5-80.—TT-309/UG of AN/FGC-59 Typing Reperforator Monitor Group.

distributors, in the form of fully perforated tape and characters printed on the tape. The tapes from the reperforators are wound by the tape winders from which a full reel of tape can be conveniently removed for storage. The group provides wiring and electrical control facilities to operate two Model 28 Multiple Typing Reperforator Sets and two Model 28 Tape Winder Sets.

**Typing Reperforator Receiving Group  
TT-308 of AN/FGC-59**

The Teletype Model 28 Typing Reperforator Receiving Group (figure 5-81) receives messages from six separate incoming lines in the form of 5 level teletype signals and converts them into fully perforated tape with characters printed on

the tape. The Group provides wiring and electrical control facilities to operate six Model 28 Multiple Typing Reperforator Sets. Slots in the cabinet provide a convenient tearing edge for the tape at the end of the message. Tape holders and tape bins are mounted on the front doors and tape clips are mounted on the top of the cabinet.

**Tape Factory**

Although only one copy of a tape message is received, routing instruction often require it to be relayed over several circuits. To avoid the delay of running a single tape through several TD's, duplicates are made by putting the tape through duplicating reperforators called a tape factory. As many as six copies can be made at one time. If more than six are needed, the process is repeated.

**ASSOCIATED TERMINAL EQUIPMENT**

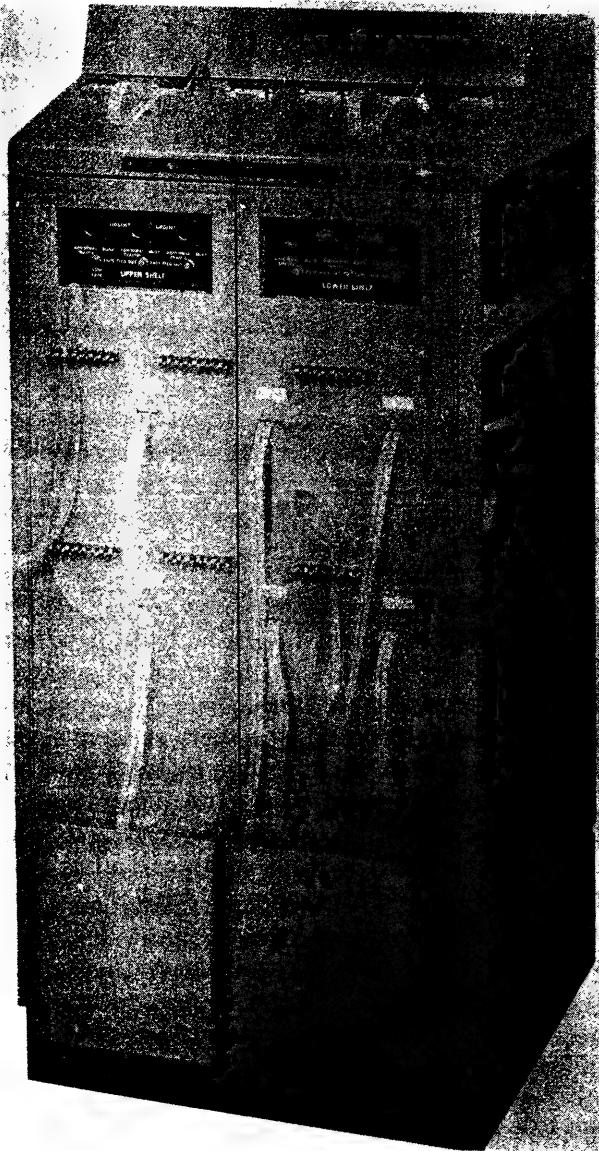
In addition to the various teletypewriter equipments just discussed, this section presents those equipments associated with the interfacing of Project STREAMLINER/AUTODIN/DSSCS. The discussions herein are only intended to be a general description of each equipment.

**Common Control  
Unit C-8120 (P)/G**

The Common Control Unit (CCU) (figure 5-82) is basically the control device for each AUTODIN/DSSCS digital terminal. Full duplex synchronous communication between the terminal and the AUTODIN Automatic Switching Center (ASC) is possible at line speeds up to 4800 baud. Digital information transmitted over the line to the ASC is divided into 80-character blocks, with each block containing four framing characters, added by the CCU, making a total of 84 characters per line block. The sending operation consists of: accepting data characters from the peripheral tape readers through the Teletype Adaptor Module (TAM) (or the NSA AUTODIN

Figure. 5-81.—TT-308 of AN/FGC-59 Typing Reperforator Receiving Group.

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Figure 5-82.—Common Control Unit (CCU).

Integration Device (NAID)), accumulating the input characters into data blocks in the CCU memory; transmitting the completed "framed" blocks and awaiting an acknowledgement code from the AUTODIN ASC. The receiving operation consists of: accepting data blocks from the line (ASC), checking for parity errors, and sending proper response code; accumulating message blocks in memory; and distributing the data blocks via the TAM (or NAID) to the output devices on a character basis.

#### TELETYPE ADAPTER MODULE (TAM)

The Teletype Adaptor Module (TAM) is used to interface the Teletypewriter Paper-tape

Readers (AN/FGT-7, 8, 9/FGA-17), high speed punches (AN/FGR-10,11), and the page printer (TT-558/G) with the Autodin Common Control Unit (CCU).

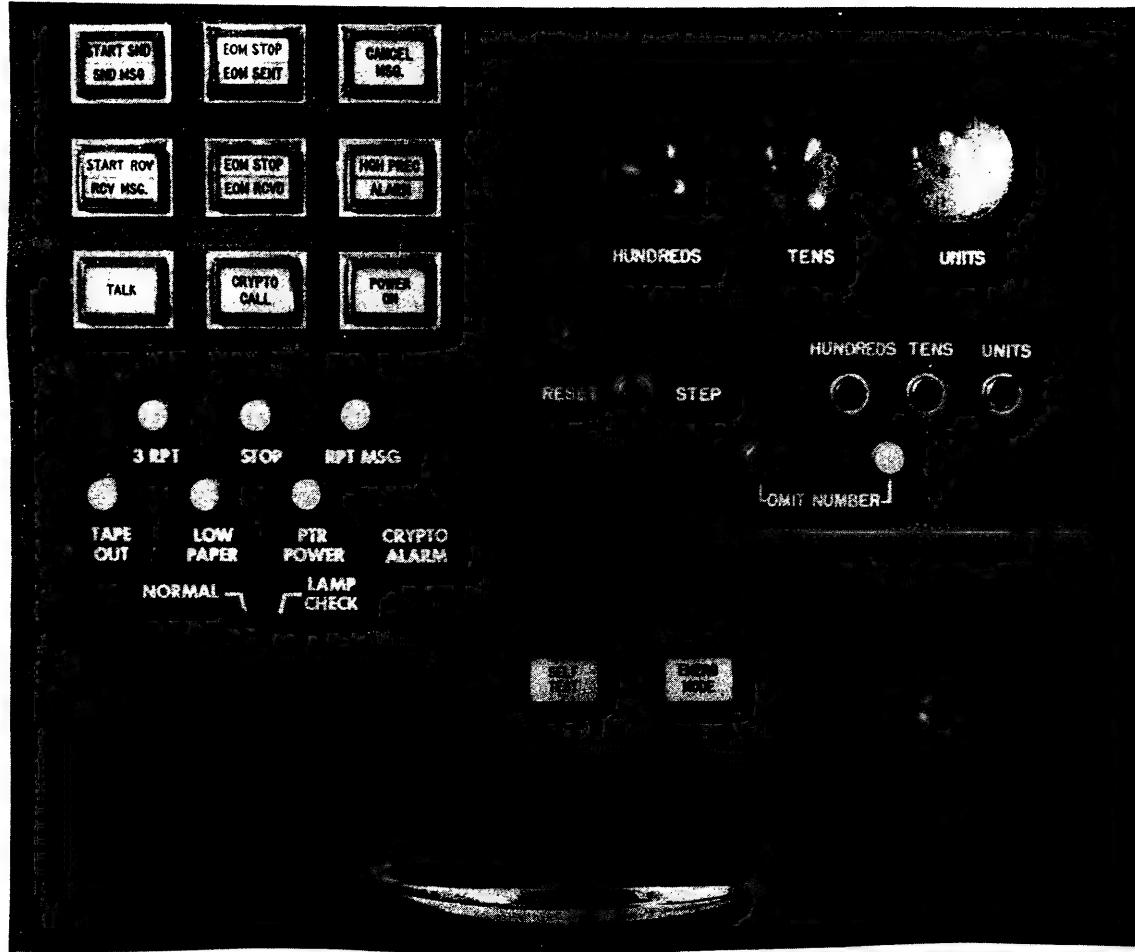
In normal transmit operation the TAM receives ITA 2 code characters from the Paper Tape Reader, converts them to the ASCII code, and feeds them to the CCU. On the receive side, the CCU feeds ASCII characters to the TAM where they are converted to ITA2 code, and then sent to the Paper Tape Punch and Line Printer. The TAM also performs serial-to-parallel and parallel-to-serial conversion of bit data because of the bit serial data transfer requirement of the DSSCS teletypewriter equipment and the bit parallel data transfer requirement of the CCU. The TAM operates asynchronously in the character stepped or bit stepped mode at 75, 150, 300, 600, 1200, 2400, and 4800 baud; full duplex.

#### TELETYPEWRITER CONTROL UNIT (TCU)

The TCU is used to control and coordinate message traffic between the teletypewriter equipment at a teletypewriter terminal and an AUTODIN switch. The TCU receives messages from a local teletypewriter and forwards them to the switch. It also receives messages from the switch and sends them to a local teletypewriter. Duplex operation is used for message transmission and reception. The TCU generates control characters and message elements and alarms the system when certain malfunctions are detected. See figure 5-83 for an illustration of the Western Union 12008A TCU. The C-7050/G is the TCU which is used overseas and is very similar to the Western Union 12008A.

#### LINE PRINTER TT-558/G

The TT-558/G (figure 5-84) is a high speed line printer capable of producing multiple page copy at rates up to 240 characters per second (3 lines of 80 characters per line) on 8-1/2 or 9-7/8 inch sprocket fed fanfold paper. An original and one to five multiple ply carbon or carbonless paper copies can be printed by the TT-558/G. The TT-558/G accepts serial input information in either the International Telegraph Alphabet



31.145

Figure 5-83.—Teletypewriter Control Unit (TCU) Western Union Model 12008A.

(ITA2) or the American Standard Code for Information Interchange modified as ITA5. These coded inputs may vary from five to eight bits per character. The TT-558/G is capable of printing 58 characters (ideograms) per column when the ITA2 code disc is used, and 64 characters when the ITA5 code disc is installed.

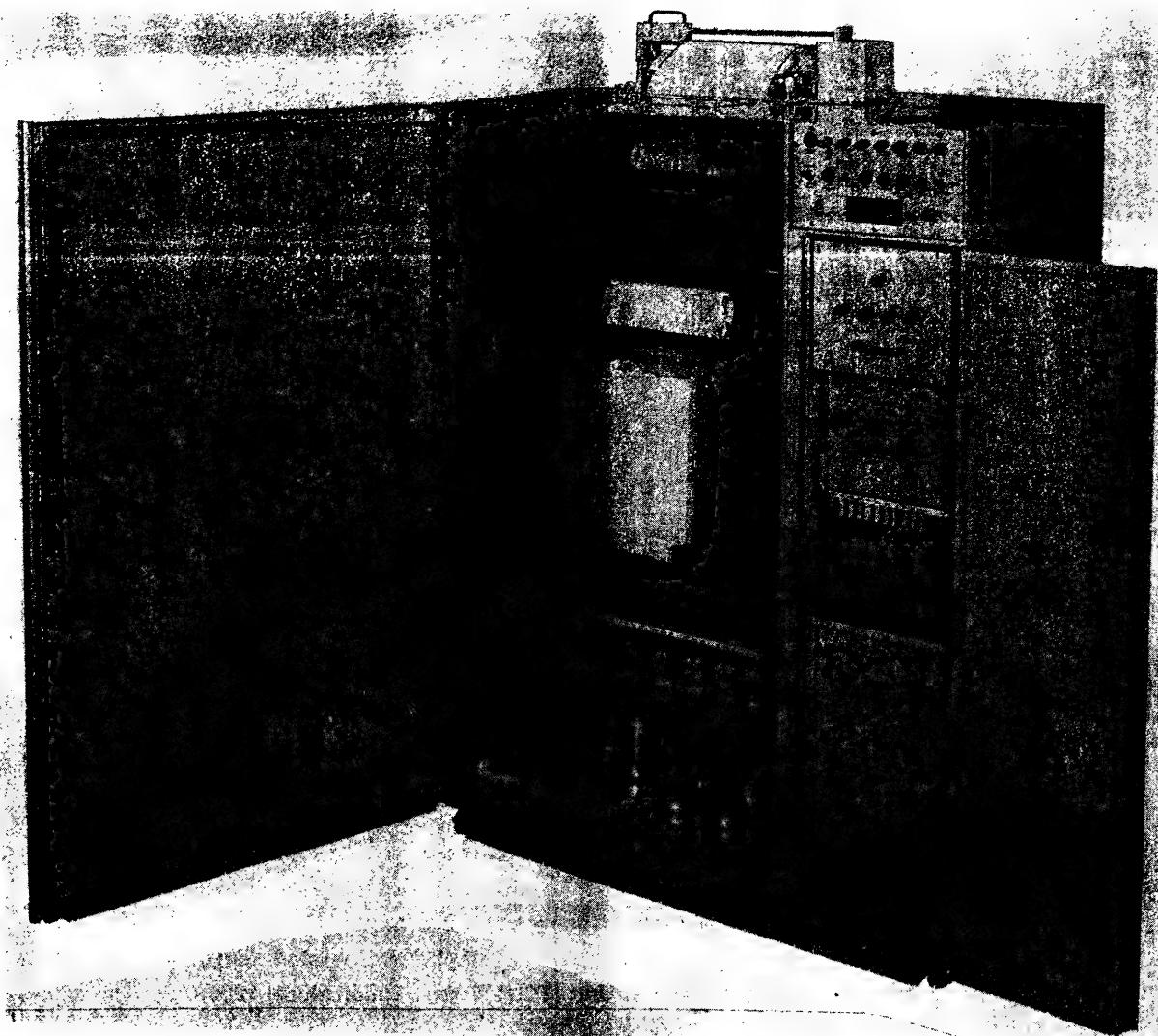
Before attempting to operate or conduct maintenance on the TT-558/G equipment, carefully study the safety precautions and the location and function of all operating controls and indicators as listed in the Technical Manual. This equipment employs voltages which are dangerous and may be fatal if contacted by personnel. Extreme caution should be exercised when working inside the TT-558/G. While every practicable safety precaution has been

incorporated in this equipment, the safety rules must be strictly observed. There are three major potential danger areas within the TT-558/G (figure 5-85). These areas are:

1. Printer drum, drum drive pulleys, drum drive belt and drum drive motor.
2. Exposed a.c. line terminals on the Printer.
3. Capacitor Bank.

#### MASTER AND SLAVE HIGH SPEED TAPE READER (AN/FGT-7, 8, 9)

The AN/FGT-7 (figure 5-86) and the AN/FGT-8 and 9 (figure 5-87) are Master and Slave High Speed Tape Readers.



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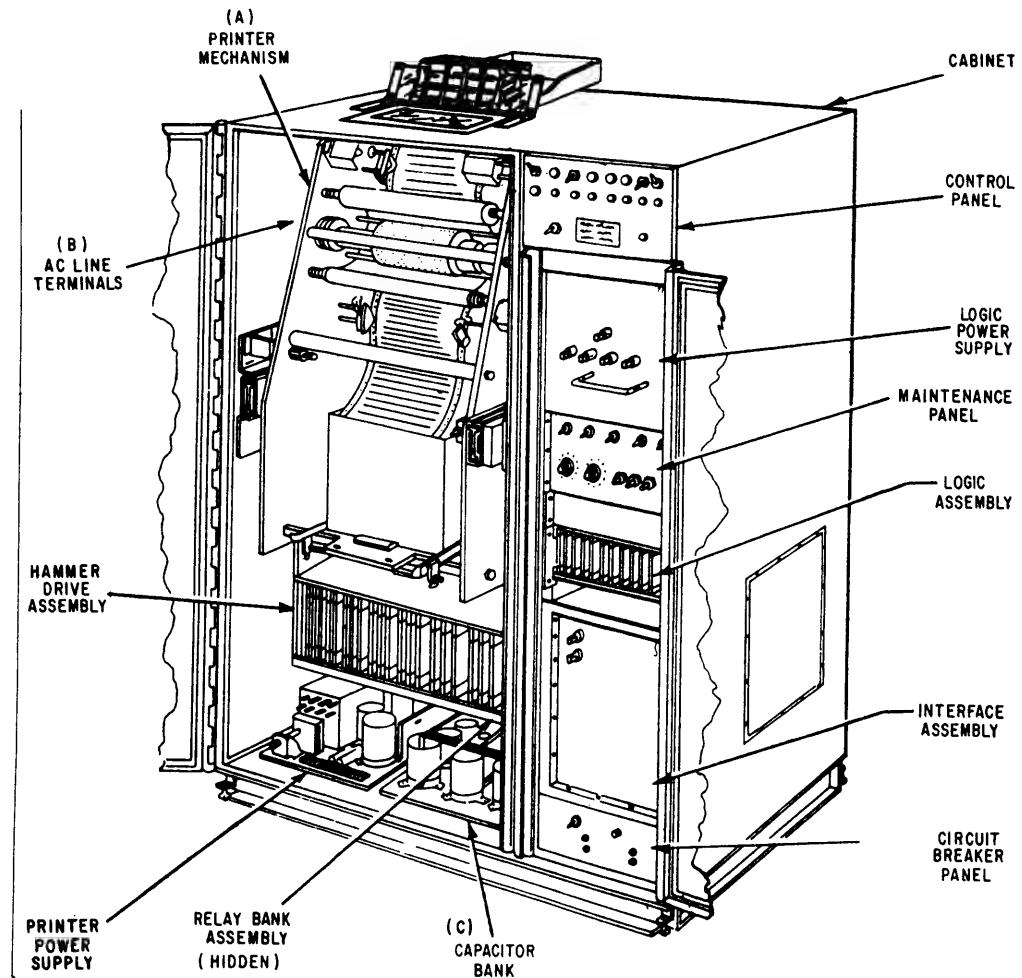
Figure 5-84.—TT-558/G Line Printer.

The Master High Speed Tape Reader controls up to five Slave High Speed Tape Readers. Its logic consists of reader control and drive circuits, message numbering, reader code, reading contact verification, feed verification, parallel-to-serial converter, reader sequencing, and power supply. The message numbering circuit automatically inserts a message number sequence before each transmission. Verification of each character is performed before the character is applied bit serially to external equipment through the parallel-to-serial

converter (parallel wire output is optionally available). The reader sequencing logic permits each reader to transmit a message in turn. Only one sends at a time, and all send before any send a second time.

The Slave High Speed Tape Reader contains reader control and drive circuits. All other logic is performed by the Master Tape Reader. Therefore, all Slave Tape Readers must operate in conjunction with a Master Tape Reader.

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Figure 5-85.—TT-558/G, Major Assemblies.

### HIGH SPEED TAPE PUNCH AN/FGR-10, 11

The High Speed Tape Punch AN/FGR-10, 11 (figures 5-88 and 5-89) consists of two high speed paper tape punches. Each high speed punch has its own tape supply, power supply, and appropriate electronic logic. The High Speed Tape Punch operates as two completely independent systems. The electronic logic contains (2 each) a serial-to-parallel converter and a punch drive.

Each system receives data either serially or in parallel at speeds up to 240 characters per

second (2400 words per minute). The data is recorded in 11/16, 7/8, or 1 inch wide paper tape, and leaves the cabinet through tape chutes at the front of the cabinet.

When data is received as a serial pulse stream, a serial-to-parallel converter changes this to a parallel wire signal and delivers it to the high speed punch drive. (Data, if received in parallel form, is applied directly to the punch drive.) The parallel signal output of the serial-to-parallel converter is available to external equipment.

The parallel output of the serial-to-parallel converter (or directly from a parallel input) is



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Figure 5-86.—High Speed Tape Reader AN/FGT-7.



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Figure 5-87.—(A) Master AN/FGT-8 (B) Slave AN/FGT-9.

converted to high power pulses by the punch drive circuits, with proper timing to drive the high speed tape punch which in turn punches the information presented to it.

#### MODEL 40 TELETYPE- WRITER EQUIPMENT

The Model 40 line of data terminals provide advanced facilities for entering, storing, displaying, editing, printing, sending and receiving data in communications systems.

Significant features of 40 terminals are: high speed, easy data preparation and editing, modular design, modern and versatile styling, quiet operation and low maintenance.

Eventually the Teletypewriter Model 40 will be used as the standard telecommunications terminal for the replacement of the TT-558/G (high speed printer) and the Model 28 telecommunications equipment described earlier in this chapter.

The Model 40 Keyboard Display (KD), figure 5-90 displays messages on a monitor that



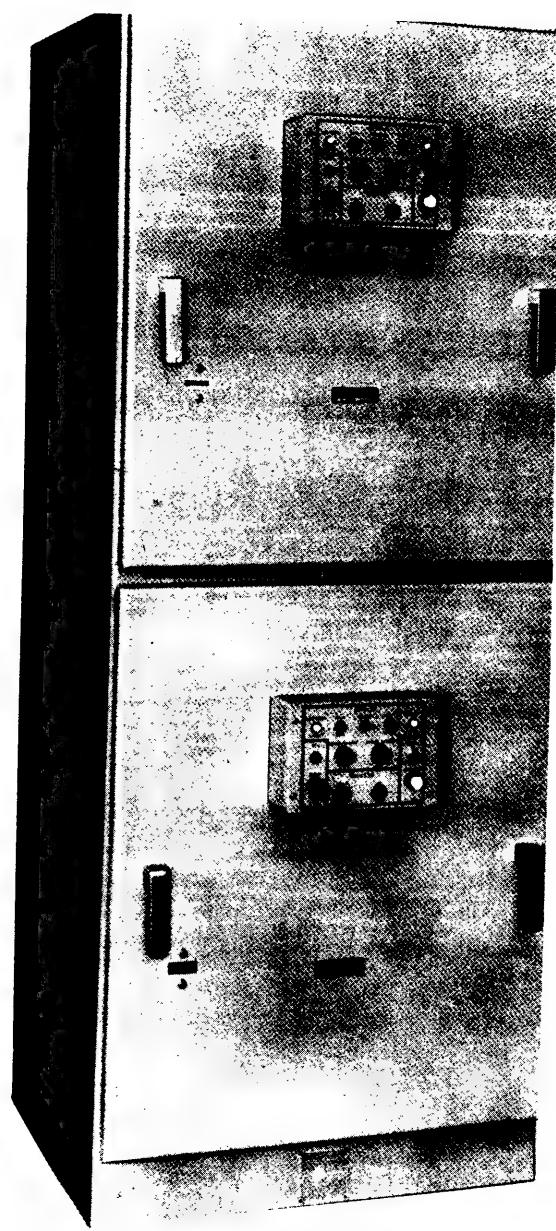
31.150

Figure 5-88.—High Speed Tape Punch AN/FGR-10.

has a screen similar to a television set. When a message is typed locally on the keyboard, it is displayed on the screen. The low-glare glass on the screen makes the display easy to read. The message can be corrected locally by using the editing controls (discussed later) prior to transmission. Received messages are also displayed.

The Model 40 Keyboard Display Printer (KDP) is similar to a KD with the addition of a page printer. The KDP consists of the keyboard, display unit, and page printer.

The KDP pedestal configuration is shown in figure 5-91, with the printer located under the



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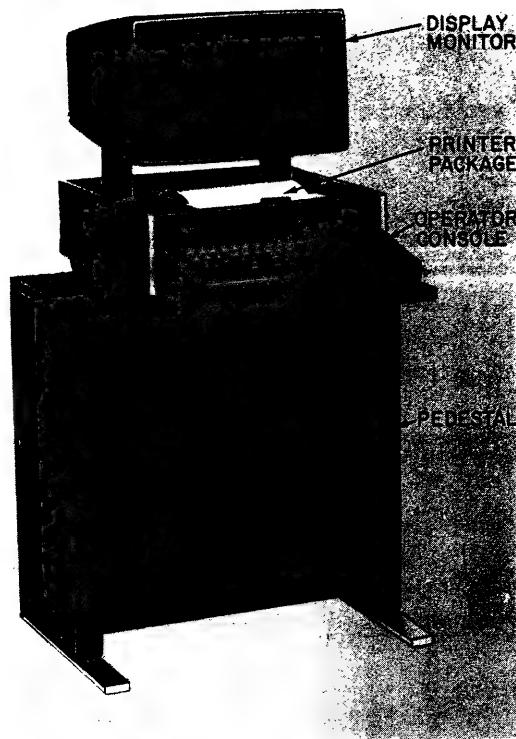
Figure 5-89.—High Speed Tape Punch AN/FGR-11.

display monitor. As you can see from the accompanying illustration (figure 5-92) the KDP is also configured as a table top model with the printer adjacent to the keyboard and display monitor. With the KDP table top model the printer may be located up to 50 feet from the unit.



Figure 5-90.—Keyboard Display (KD).

31.152      Figure 5-91.—Keyboard Display Printer (KDP) Pedestal Mounted.



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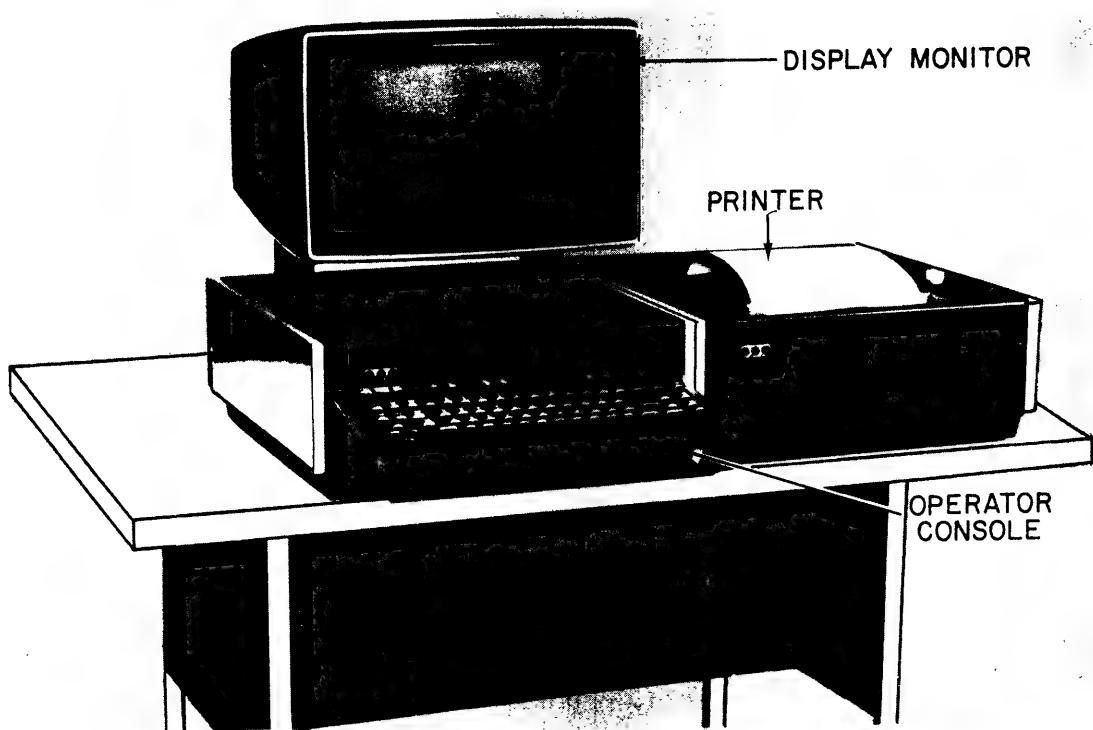


Figure 5-92.—Keyboard Display Printer (KDP) Table Mounted.

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The Model 40 KD and KDP contain a storage unit that "remembers" all characters and control functions indicated on the screen. Any errors shown on the screen can be corrected locally, so that when the corrected message is displayed it can be transmitted error free.

The Model 40 Receive Only (RO) (figure 5-93) receives messages on a hard copy page printer and has its own set of operational controls.

#### Local Operation (KD & KDP)

Power to the Model 40 KD and KDP is applied by switches located on the printer or

electronic package cabinet, the pedestal and the display monitor as illustrated in figure 5-94. Power to the display monitor may be turned off (KDP only) when the set is in receive or if PRINT ON LINE is selected to receive page copy. The keyboard is inoperative when the power to the display monitor is turned off.

The brightness control increases and decreases intensity of displayed characters. Each character is formed on a 7 x 9 dot matrix (figure 5-95) and displayed on a flicker free antiglare screen.

The unique tube tilt control allows the operator to adjust the display viewing angle for maximum clarity.

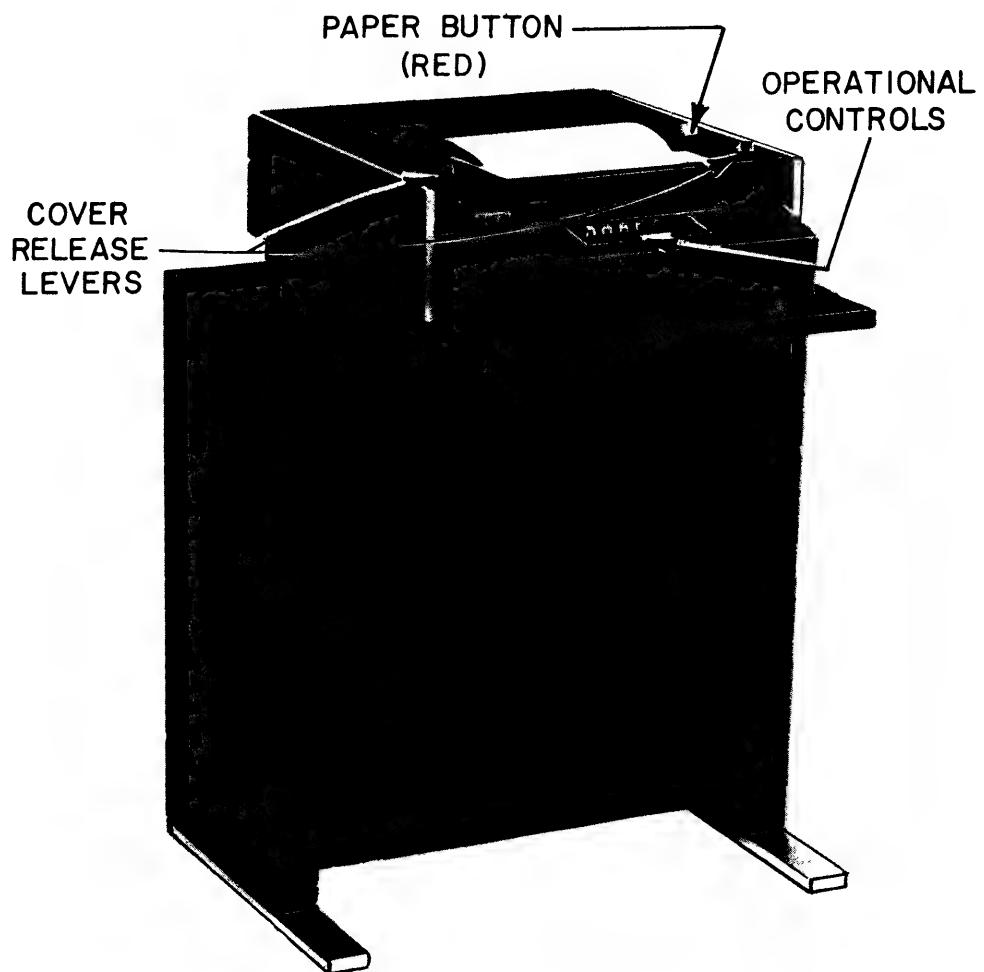
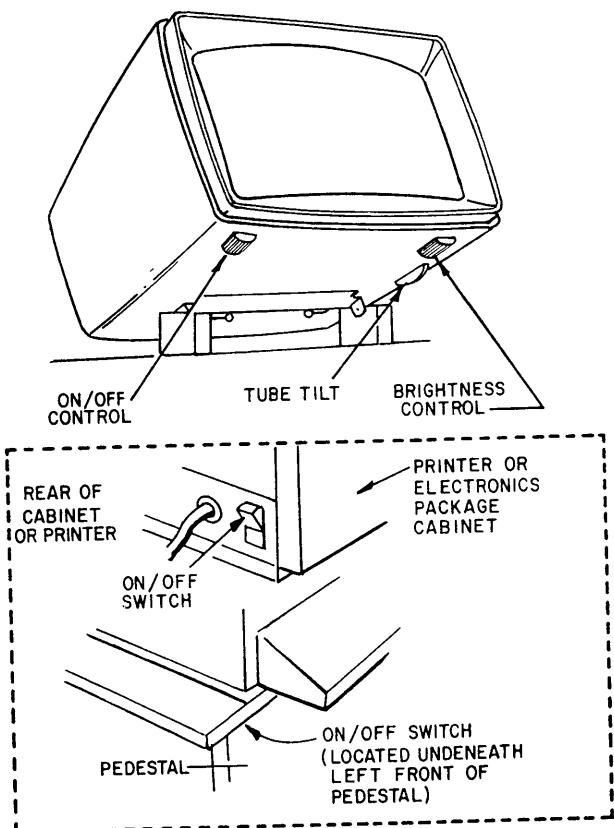


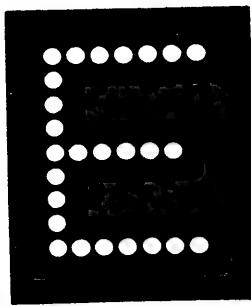
Figure 5-93.—Receive Only (RO).

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Figure 5-94.—Model 40 Power and Control Switch.



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Figure 5-95.—Character Formed on a 7X9 Dot Matrix.

### Cursor

The cursor is a light rectangular area on the screen that indicates where the next character will be displayed or the next function will take

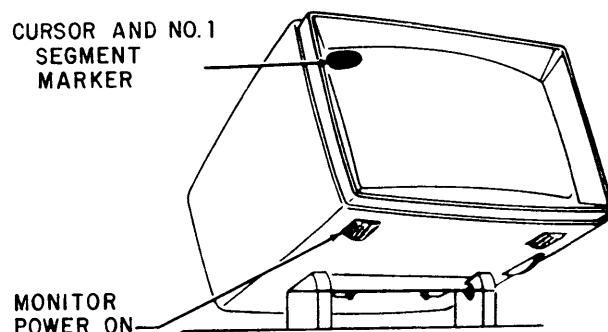
place. The cursor is always on the screen when the monitor is on. (If the display monitor power is turned on and after a slight delay the cursor and No. 1 segment marker should appear as shown in figure 5-96.)

When main power to the set and logic printer power is first turned on, the cursor may not be in the home position or random characters may be displayed on the screen. This is caused from power variations when power to the entire set is turned on. It will be necessary to depress HOME and then CLEAR keys to clear the display screen and home the cursor. The HOME and CLEAR keys are discussed in the following paragraphs.

### Operator Console

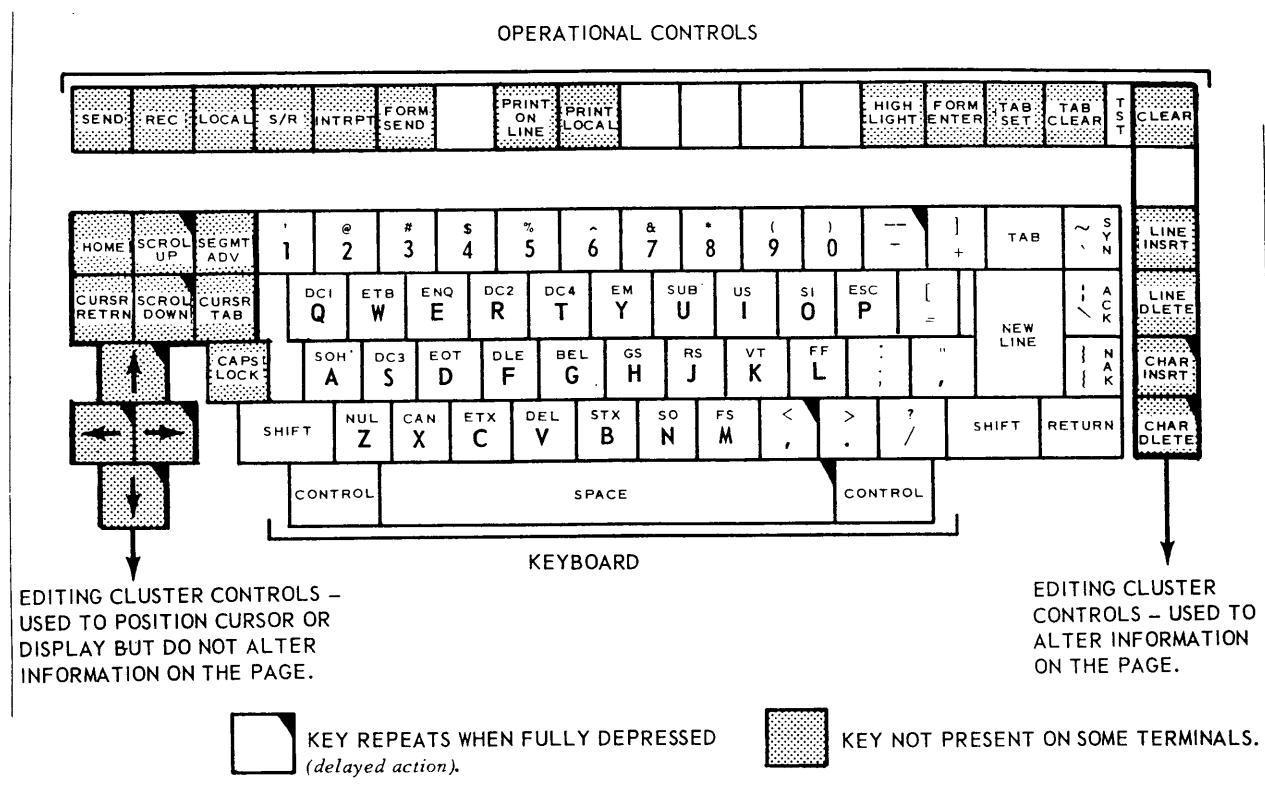
In addition to the standard keyboard arrangement necessary to generate all ASCII code characters, there are several control keys unique to the Model 40. Figure 5-97 is an illustration of the Model 40 operator console. Data entry keys, data editing keys and data communication keys are clearly separate from one another for ease and efficiency of operator use. The discussion that follows explains and illustrates the various features of the operator console by Operational Mode controls, Editing controls, and the keyboard.

**OPERATIONAL MODE CONTROLS.**—The Operational Mode Controls (top row of keys shown in figure 5-97) normally light when



31.158

Figure 5-96.—Cursor on Display Monitor.



31.159

Figure 5-97.—Model 40 Operator Console.

depressed and indicate the operational mode of the terminal. The keyboard and editing controls will not operate on the SEND or RECEIVE mode. Each of the function control keys are defined as follows:

1. SEND—Puts terminal in send mode and sends all data in display memory to the line, from the cursor location to the ASCII control used to halt transmission or to the end of memory, in accordance with send option elected.
2. REC—Puts terminal in receive mode and permits it to receive data from the line, from the cursor location to the end of the display memory.
3. LOCAL—Puts terminal in local mode and permits data to be entered.
4. S/R (Send /Receive)—Puts terminal in conversational mode and permits conversation communication to take place.

5. INTRPT—Stops transmission from remote device by sending interrupt signal.

6. FORM SEND—Over-rides the send options associated with the SEND key and causes all data to be sent as displayed, whether protected or highlighted or not, including tab stops, when the SEND key is depressed.

7. PRINT ON-LINE—Puts terminal in receive mode, unless SEND key was depressed, and permits terminal to receive data on the printer and the display module, unless display module is turned OFF. Data is displayed from cursor location to end of display memory if display is ON. If SEND was depressed, PRINT ON-LINE causes sent data to be printed as sent, according to send option.

8. PRINT LOCAL—Causes printer to print all data in display memory regardless of send option, from cursor location to end of display memory.

9. HIGHLIGHT—Causes characters that follow to be displayed as highlighted characters.

10. FORM ENTER—Puts terminal in protected data mode, during which all data entered will be displayed as protected data. Operation of the CLEAR key will clear protected and unprotected data from memory, and operation of the editing keys will effect both protected and unprotected data.

11. TAB SET—Sets tab stops at cursor location on that line and all lines below, to end of display memory.

12. TAB CLEAR—Clears all tab stops from the cursor location to the end of the line, on that line and all lines below to the end of display memory.

13. CLEAR—Clears all unprotected data from the cursor location to the end of the display memory. To clear all data from the cursor location to the end of the display memory, whether protected or unprotected, depress the FORM ENTER and then the CLEAR keys.

**L E F T - H A N D E D I T I N G C O N T R O L S.**—These keys position cursor or displayed data, but do not alter information on the page. Additionally, the left hand editing controls operate only in the local mode. Figure 5-98 illustrates the various positions of the cursor and scroll as a result of depressing one of the left hand editing controls. The left hand editing controls are defined below. (Refer to figure to identify the action performed by each key.)

1. HOME—Causes first segment to be displayed and moves cursor to start of first line.

2. CURSR RETRN—Moves cursor to start of line.

3. Up arrow, left arrow, right arrow and down arrow (Repeatable)—Moves cursor up, left, right and down, respectively.

4. SCROL UP AND SCROL DOWN (Repeatable)—Moves displayed data up and down respectively.

5. SEGMT ADV—Removes the 24 lines being displayed and displays the next whole 24 line segment. A page may consist of 1, 2, or 3 segments of 24 lines each. The three segments contain a total of 72 lines; each line contains a maximum of 80 characters.

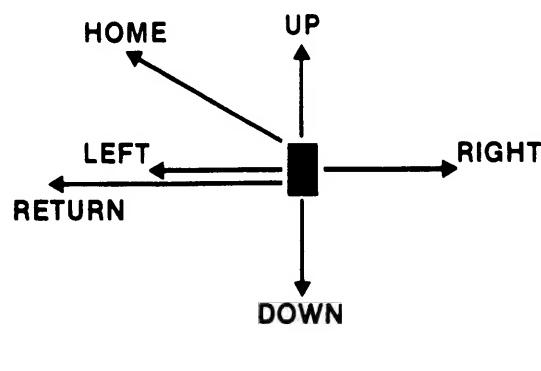


Figure 5-98.—Left-Hand Editing Controls.

6. CURSR TAB—Moves cursor to the first tab stop on the right, or to the start of the next line, or to the first unprotected character following protected data, whichever comes first.

**R I G H T - H A N D E D I T I N G C O N T R O L S.**—Operation of these keys can be affected when protected data or tab marks are present. These keys alter information on the page and operate only in the local mode. The right hand editing controls are defined as follows:

1. LINE INSERT—Moves unprotected data down one line, so that there is a line of space on

the line the cursor is on. Does not occur if there are no lines of space at the end of the display memory or if there are no lines of space above the first line below having protected data in it.

2. LINE DLETE—Clears unprotected data from the line the cursor is on and moves all unprotected data displayed below up one line.

3. CHAR INSRT (Repeatable)—Moves unprotected data one character to the right so that there is a character of space at the cursor location. Does not occur if there are no character spaces ahead of the first protected character or the first tab stop displayed on the right.

4. CHAR DLETE (Repeatable)—Clears unprotected character at cursor location and moves all unprotected data displayed on the right one character position to the left.

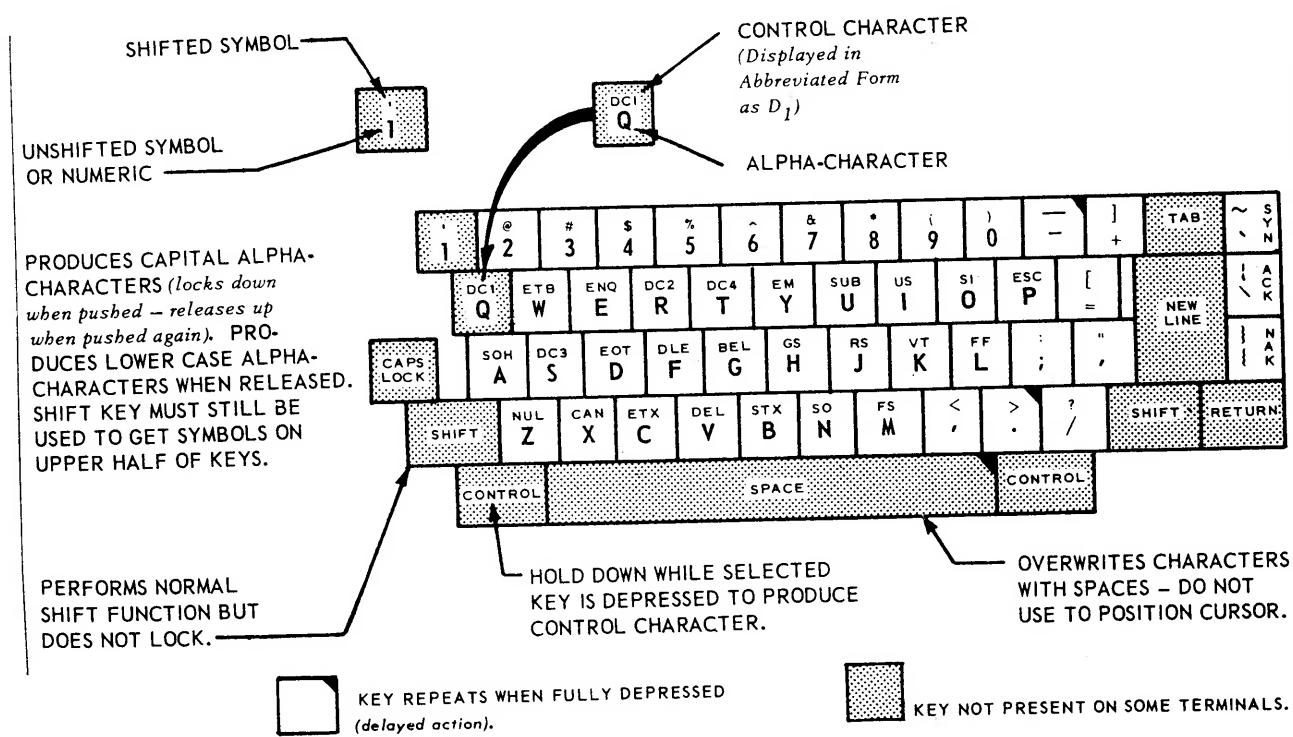
KEYBOARD.—Figure 5-99 shows the remainder of the operator console which resembles a standard keyboard arrangement. Depressing a key by itself generates the

character marked on the lower half, or the control marked in the center. Depressing a key with the SHIFT key generates the upper case equivalent of the character marked on the lower half, or the character marked on the top half of the key. Depressing a key with the CONTROL key generates the control marked on the key.

### Printer Operation

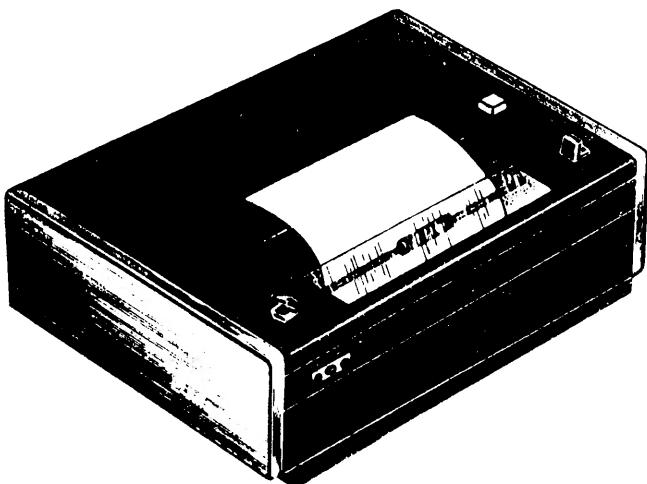
The page printer, (figure 5-100) if present, provides a hard copy of messages originated locally or messages transmitted or received on-line. Two of the Operational mode control keys located just above the keyboard control the operation of the page printer. They are the PRINT LOCAL and PRINT ON LINE keys.

Depressing PRINT LOCAL (lamp lights; SEND lamp will also light) will provide a printed copy of data on the display from cursor position. The cursor will move through the display to the message ending character.



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Figure 5-99.—Keyboard.



31.162

Figure 5-100.—Page Printer.

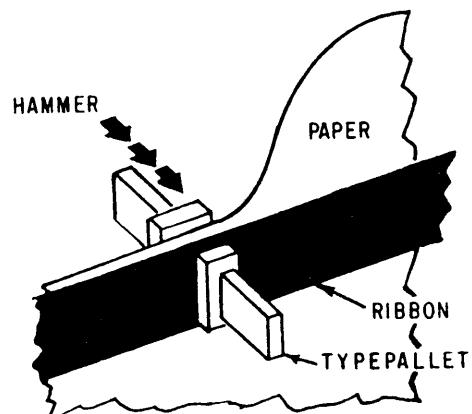
The PRINT ON LINE when depressed (lights), will provide printed copy of any data transmitted or received on-line. It will light until depressed again.

The button located on top of printer is the PAPER button and is red in color. When depressed, paper in page printer advances. Paper feed-out will be continuous until button is released. PAPER button lights when an out-of-paper condition exists and extinguishes when paper supply is replenished.

The 40 printer module prints characters by means of individual typepallets in an endless revolving carrier belt. (See fig. 5-101.)

With this method you gain high speed operation without losing the character clarity and changeability advantages of an impact typebox printer.

Producing the printing are 80 print hammers, one for each print position. They strike the paper into the ribbon and onto the typepallets, as the typepallets fly by on their continually moving carrier. They produce crisp impact printing of full characters, not dots arranged to look like characters. With 80 print hammers, each hammer is doing only 1/80th of the work, at 1/80th of the printing speed. This means longer printer life and less maintenance



31.163

Figure 5-101.—Individual Typepallet and Hammer.

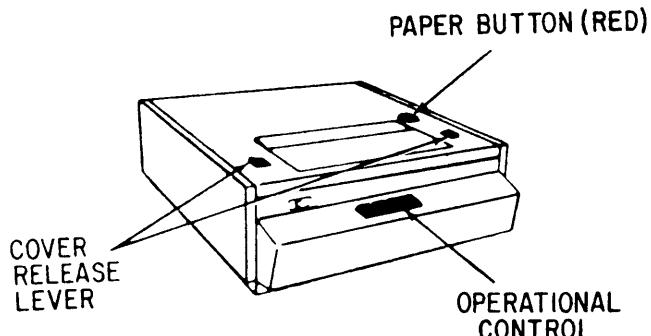
even though the printing speed is much higher than that of conventional printers.

**RAPID PRINT-OUT RATE.**—The full ASCII printer prints up to 3.7 lines per second with up to 80 characters per line, for a maximum capability of almost 300 characters per second.

The monocase ASCII printer prints up to 5.2 lines per second, with up to 80 characters per line for a maximum capability of almost 420 characters per second.

#### Receive Only Page Printer Operation

The Receive Only Page Printer, figure 5-102 provides a hard copy of messages received



31.164

Figure 5-102.—Receive only Page Printer.

on-line. The Receive Only set has its own set of operational controls and are defined as follows:

1. INTRPT—Sends reverse channel signal to halt remote sender, should reception become garbled or unwanted.
2. TRANS START—Sends discrete calling code to remote device when terminal on-line. Generates test data when terminal off-line.
3. IN SERVICE—Terminal ready, i.e., power on, no low paper supply, etc.
4. DATA ERROR—Illuminates on receipt of character with parity error.

Also with the receive-only printer terminal comes a test data generator. With this feature the operator can push a button and generate a sequence of characters which will test the terminal for proper operation.

The printer normally prints six lines to the inch but can be selected to print three lines to the inch by moving the single/double line feed lever (located under the printer cover) from 1 to 2.

#### Built-In Diagnostics

As reliable as the 40 is designed and built, sometimes things can still go wrong. But when

they do the maintenance man is not alone with the problem. There is built-in help.

Should a malfunction occur in the display module, for example, there's a series of neon glow tubes which are visible from the outside, mounted on circuit cards inside. A quick glance at these neon tubes tells him which card is not functioning properly.

For another example, the terminal logic can be checked out by pressing pushbuttons on circuit cards inside terminal and observing test patterns on the display screen. The card that doesn't display its proper pattern is the card that has the defective component.

Even the operator console can be checked for proper operation. Combinations of keys, depressed below their normal downstop, illuminate indicators on the console if the console is working properly.

Once the trouble is isolated, either circuit cards or whole modules can be easily exchanged, whichever is more efficient for the maintenance man. This is because the display module, printer and operator console, as well as the circuit cards feature a combined mechanical-electrical connection with the rest of the terminal for rapid replacement.